OPTIONS FOR THE NEXT ACT WATER SOURCE

Prepared for

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by

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Executive Summary

This report is written at a time of great change in the ACT.

The ACT Government is redefining the direction of Canberra. Final reports on the future of urban and non-urban Canberra, the *Canberra Spatial Plan*, the *Economic White Paper*, the *Canberra Social Plan* and the *ACT Water Resources Strategy* all have been recently released.

In the past, predicting when a new water source was needed for the ACT involved estimates of population growth, measuring existing water consumption patterns, current environmental flows and assuming no drought worse than previously recorded. This information was then modelled to predict the timing of a new supply based on the size of the population that could be served. The output from this model identified the need for a new water supply when the population of the ACT and Queanbeyan reached 405,000. The Australian Bureau of Statistics mid-range forecast estimates this population would be reached in 2017. There is now a need to re-examine these assumptions, as well as the modelling methodology, and include effects due to bushfires, climate change, climate variability, water consumption and possible water supply to NSW. The duration and frequency of restrictions also needs further consideration.

A preliminary assessment suggests that likely timing for a new water source will need to be bought forward. On the other side, meeting the 12 per cent reduction in water use as outlined in the ACT Government's Water Resources Strategy would help to defer the need for a new water source for the ACT. ACTEW is committed to working with the government to meet this water use reduction target and our planning assumes the target will be met.

We are in a drought that may become the worst in our 90 years of record. We have recently experienced a devastating bushfire, which amongst other things, burnt out the entire Cotter water catchment. A report by CSIRO and the CRC for Catchment Hydrology indicates that the ACT is likely to see more variable rainfall, higher temperatures, and a reduction in rainfall as well as a reduction in run-off into the water storages. These changes in climatic conditions, together with a relatively short period of climate record, suggest that the current planning is more complex than it has been in the past.

While this report primarily address the options for a new water source for the ACT, it also identifies contingency planning if the current drought were to continue. This planning initially identifies the use of the Lower Cotter Dam as a component of the ACT's water supply system. Use of the Cotter Dam will be possible following the commissioning of the new water treatment plant at Mount Stromlo (at the end of 2004) permitting treatment of a wide range of water quality. But, if sufficient rain does not fall it is unlikely that this will defer the need for further water restrictions. The next step being investigated is to access water from the Murrumbidgee River. This is similar to the situation used in 1968, when water was released from Tantangara Reservoir into the Murrumbidgee River and then pumped into Cotter Dam. This contingency plan is being developed in the event of a continuation of the drought for the remainder of 2004, and beyond and an increase in the severity of the drought. While the existing drought is similar to the 1940s drought, a continuation or worsening of the drought would be unprecedented in Canberra's history. Given, however, the essential requirements of water to the ACT, ACTEW is developing contingency plans for such an event to ensure the continuing security of the ACT's water supply.

In examining options for the next water source for the ACT, this report has re-assessed schemes proposed previously and developed some new options, each considered in the light of modern

Canberra. This report is not an exhaustive analysis of inter-jurisdictional, social, economic and environmental issues. It is intended to identify the options for further analysis so that the more detailed analysis can be undertaken in conjunction with the community of the ACT. This document provides the initial basis to generate these discussions, which will also include issues associated with the ACT's position in the Murray-Darling Basin and our responsibilities under various inter-governmental agreements.

The decision to proceed with a new supply is one of risk management. This involves balancing the likelihood for water restrictions (particularly Stage 2 and beyond), the predicted changes in population and climate (including the uncertainties of these predictions) and the cost and other impacts of providing a new water source for the ACT.

The report is based on a three-staged approach:

Stage 1	Preliminary investigation of nearly 30 possible options.
Stage 2	Eleven options based on four water sources underwent more detailed analysis (see table on next page).
Stage 3	Recommended options for detailed evaluation (see map on next page), these are: building a new dam near Mt Tennent; enlarging Cotter Dam; transferring water from Tantangara to Canberra.

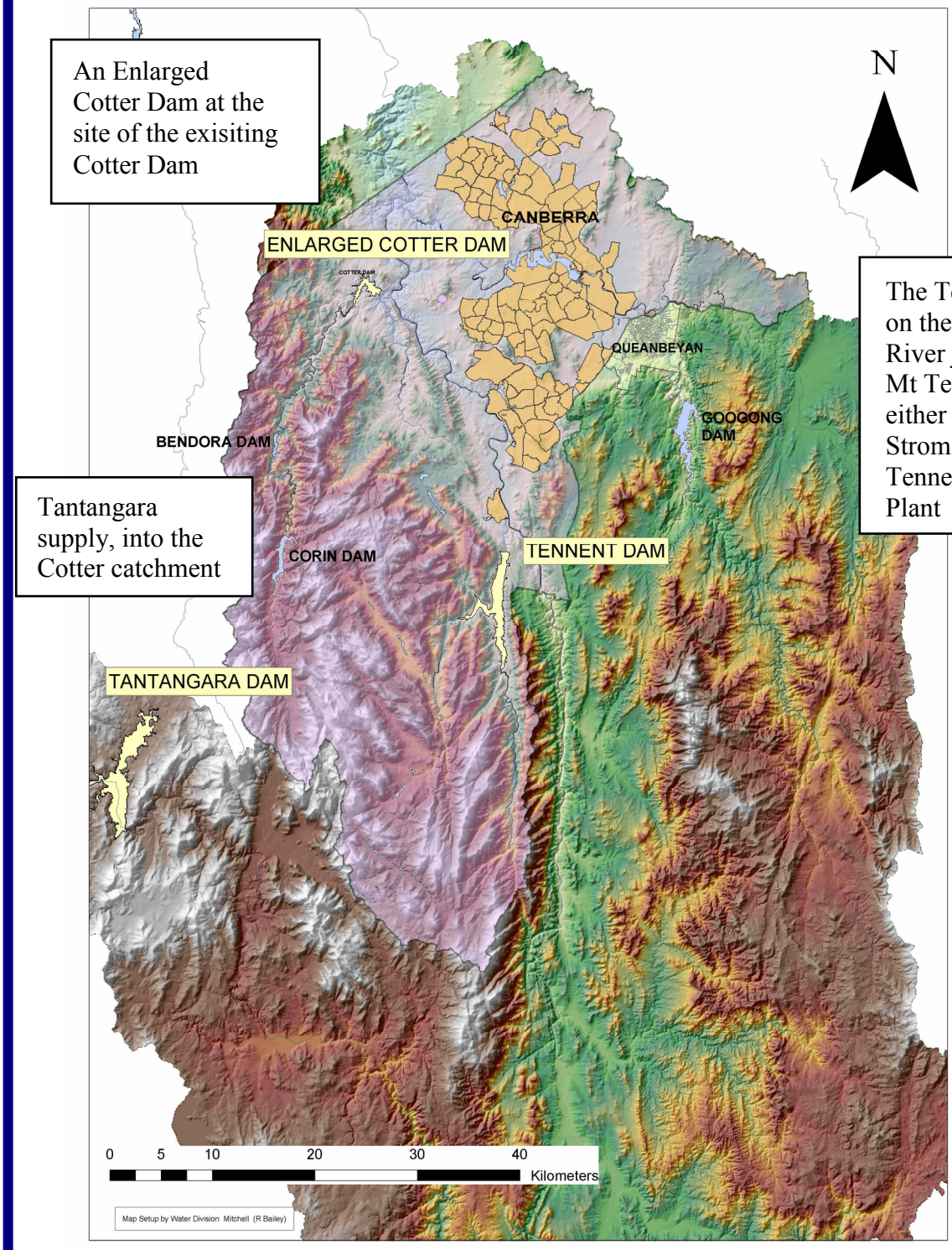
Stage 2 Shortlisted options - summary of capital, NPV and $m/GL yield costs

Option	Total Capital Expenditure $ (2012) Million	Net Present Value in 2012 for a supply in 2017[1]	Cost per GL of Yield	
		$ Million	$M/GL	Rank
Enlarged Cotter	**102.6**	**91.7**	**5.4**	**7**
Tennent-Stromlo	**131.0**	**125.4**	**3.9**	**4**
Tennent-Tuggeranong	**130.3**	**125.3**	**3.9**	**4**
Tantangara – pumped	**94.2**	**87.4**	**3.5**	**2**
Tantangara – tunnel	**107.5**	**90.4**	**3.6**	**3**
Tantangara – Yaouk Valley to Porcupine Creek	**67.7**	**64.0**	**2.6**	**1**
Tantangara – Yaouk Valley gravity pipeline	**117.2**	**97.6**	**3.9**	**4**
Coree Arch – to Bendora Gravity Main	**101.8**	**98.6**	**6.5**	**8**
Coree Arch – to Coree Gravity Main	**126.8**	**122.2**	**8.1**	**10**
Coree Embankment – to Bendora Gravity Main	**128.8**	**124.0**	**7.3**	**9**
Coree Embankment – to Coree Gravity Main	**153.8**	**145.5**	**8.6**	**11**

The preferred options are summarised in the diagram below. It is also possible that these options could be staged, to reduce the initial cost and to provide water in line with population growth, rather than having a large supply that is not needed for many years.

[1] Note for a dam in 2017, it has been assumed that expenditure on construction would start in 2012.

Stage 3: Preferred water source options



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WATER SUPPLY IN THE ACT

A short history of water supply development

The construction of Canberra's first dam at the Lower Cotter started in 1912. Although it was designed to be 30.5 metres high, cost savings led to it being constructed to 18.5 metres. It had a capacity of about 1.8 Gigalitres. The work included a pumping station on the Murrumbidgee River and a 450mm rising main to a water reservoir on Mt Stromlo. The overall system became operational in 1918. Between 1949 and 1951 the dam wall was raised to 31 metres, providing the present day storage of 4.7 Gigalitres.

In the early 1950s the Department of Works proposed a dam on the Queanbeyan River near Googong Station. Concerns about the quality of the water led to it being rejected by the Commonwealth Parliamentary Standing Committee on Public Works. In 1955 a new dam on the Cotter River was approved. The Bendora Dam was constructed between 1958 and 1961. The 47 metres high dam wall provides a storage capacity of 10.7 Gigalitres.

In 1963, in anticipation of the rapid development of Canberra the National Capital Development Commission started design work for the Corin Dam some 11 kilometre upstream of the Bendora Dam. Construction commenced in 1966 and was completed in 1968. The earth and rock filled embankment is 72 metres high and provides a further 75.4 Gigalitres of water storage.

It is worth noting that 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 Stromlo.

The Mt Stromlo Water Treatment Plant (WTP) was completed in June 1967, enabling the treatment of the water before distribution to Canberra and Queanbeyan. This plant, which has sedimentation capability (but has no filtration capability), has a design capacity of 60ML/d. This plant has been re-commissioned to help deal with the water quality problems arising from the recent bushfires.

The Bendora-Mt Stromlo main (known as the Bendora Gravity Main) was completed in 1968, allowing water from Bendora Dam to flow by gravity to Stromlo. This resulted in significant savings in pumping costs, and treatment, as water from Bendora did not require treatment. The Bendora Gravity Main is a key component of Canberra's water supply system today.

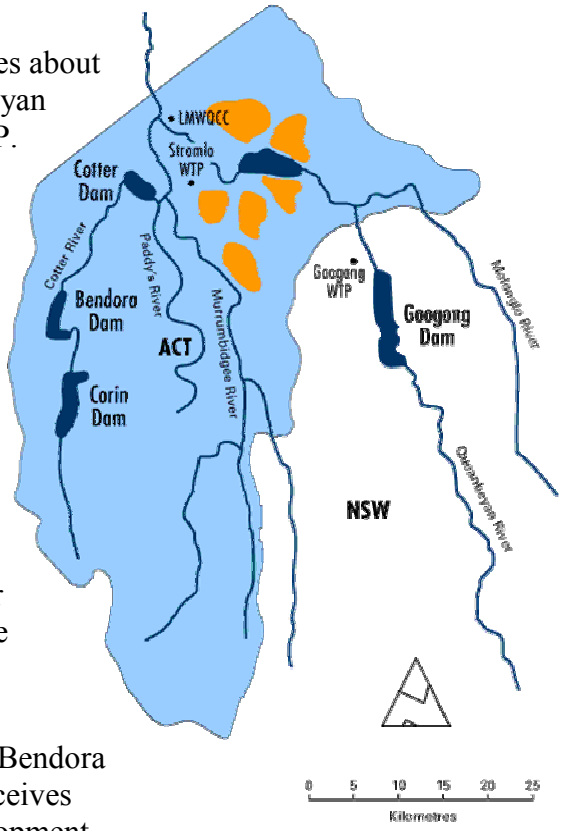
Under the *Seat of Government Acceptance Act 1909* the Commonwealth was granted the rights to the waters of the Molonglo and Queanbeyan rivers for the purposes of water supply. With the high population growth rates of the late 1960s and early 1970s the Commonwealth reached agreement with the NSW Government in 1972 for a further dam at Googong on the

Queanbeyan River. Construction commenced in 1975 and was completed in 1978. The dam wall is some 66 metres high, providing water storage for 125 Gigalitres.

During the 1980s the Commonwealth Bureau of Meteorology substantially revised its calculations of the maximum probable rainfall, which more than doubled the design floods. The ACT and Googong dams have all been modified to safely handle these higher flood flows.

Two catchments provide Canberra's water supply

Figure 1: Canberra Water Supply Schematic



The Cotter catchment with three storage dams supplies about 60 per cent (yield capacity) of the Canberra-Queanbeyan water needs, distributed through the Mt Stromlo WTP. The Googong Dam and Water Treatment Plant (WTP) provides the remainder.

Historically, water from the Cotter catchment has been preferred because it required only disinfection and fluoride addition before distribution. Additionally, no pumping is required and some of the residual energy is used to generate a small amount of power. This not only keeps the cost of using this water low but also provides environmental benefits: by not contributing to greenhouse gas production and through the power generated by the mini hydro facility. All of the water from Googong must be pumped some 50metres to the Googong WTP and fully treated before distribution.

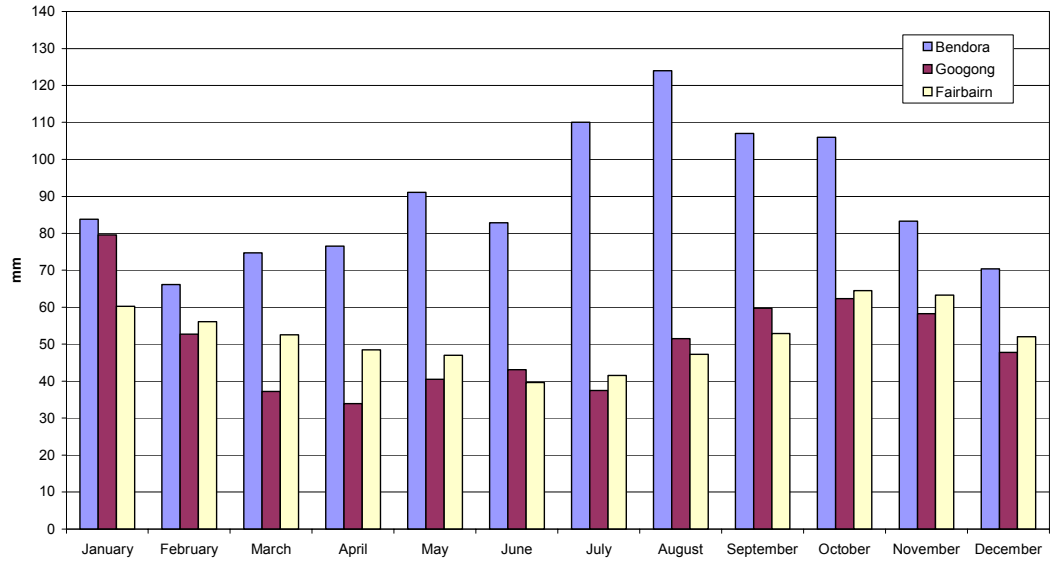
The Cotter catchment

The Cotter catchment, particularly the section above Bendora Dam, is high up in the Brindabella Mountains and receives high rainfall. The catchment is protected from development, resulting in high water quality. Water is stored in the Corin and Bendora dams, primarily Corin, and flows by gravity from Bendora Dam to Stromlo WTP from where it is distributed to Canberra and Queanbeyan.

Whilst historically water from Bendora and Corin dams did not require treatment, the January 2003 bushfires changed that. A treatment plant is being built at Stromlo, capable of treating 250 megalitres per day (ML/d). It is anticipated to become operative during the 2004/05 summer.

The average annual rainfall at the upstream end of the Corin section of the Cotter catchment is around 950mm, compared with 600mm at Canberra Airport and 650mm at Googong Dam (Figure 2 shows the monthly variation at the three sites). The average evaporation of the Cotter catchment is about two thirds of that in the city.

Figure 2: Average Monthly rainfall for various catchments



Average Monthly Rainfall for Various Canberra Catchments

Googong catchment

The Googong Dam is about 20 kilometres southeast of Canberra on the Queanbeyan River. Water pumped from it requires full treatment as the Queanbeyan River flows through a mixture of heavily timbered country, agricultural land, used mainly for grazing and rural residential blocks. The Googong catchment is about three times larger than the Cotter catchment but it receives much less rainfall and has higher evaporation. The long term average rainfall in the catchment is around 650mm per year and evaporation rates from Googong dam are about 1400mm per annum. These factors contribute to the lower yield of the Googong catchment compared to the Cotter catchment.

The water is treated at the Googong WTP before distribution. The Googong WTP is being upgraded from 180ML/d to 270ML/d – the upgrade program is expected to be completed by Spring 2004.

Planning context

National/ACT planning frameworks

Planning and development in the ACT has to meet the national interest on behalf of all Australians, and provide for the interests of the Canberra community.

Nationally this requires protecting and enhancing the significance of the Territory as Australia's National Capital. This is achieved through the National Capital Plan (NCP), the Commonwealth's plan for the National Capital, which is prepared and administered by the National Capital Authority under the *Australian Capital Territory (Planning and Land Management) Act 1988*. At the Territory level, and in a manner not inconsistent with the National Capital Plan, the Territory Plan guides planning and development. The Territory Plan is prepared and administered by the ACT Planning and Land Authority under the Territory's *Land (Planning and Environment) Act 1991*.

Future water supply planning is a key element of the National Capital Plan (see Appendix G of the Plan: "Requirements For Namadgi National Park And Adjacent Areas - (Including Namadgi National Park and adjacent areas of the Cotter and Gudgenby Catchments")).

Figure 3: Sub-catchments boundaries – extract from National Capital Plan

In summary the National Capital Plan sets aside Tennent and Coree as possible future Canberra water supplies. Figure 3, an extract from Appendix G, specifies:

- the area (in green) covered by this part of the NCP;
- the location of Tennent and Coree Dams (as well as Cotter, Bendora and Corin Dams).

Appendix G includes these two key policy statements for this area:

Key objectives: To protect the resources and environmental qualities of Namadgi National Park and adjacent areas of the Cotter and Gudgenby catchments in the interests of Canberra's water supply and nature conservation. Plantation timber production in the north of the Policy Area, recreation and scientific study are secondary objectives.

Water supply: To protect the Cotter and Gudgenby catchments for Canberra's water supply so as to maintain or improve yield in terms of quality, quantity and reliability. The

quality of water supply in the Cotter catchment to be assured primarily by controls over catchment uses rather than by the use of additional treatment.

Strategies in development that will redefine Canberra

A number of significant strategies were developed or completed in 2003 that will help decide both the location and the timing of the next ACT water supply. They include:

- *ACT Government, November 2003, Shaping Our Territory. Final Report:* Opportunities for Non-Urban ACT
- *ACT Planning and Land Authority, November 2003, The* Draft Canberra Spatial Plan.
- *Environment ACT, 2004, ACT* Water Resources Strategy, April 2004.

Of particular relevance to future water supply location is the preferred proposal in the *Draft Canberra Spatial Plan* for development in the Molonglo Valley, and on the Kowen plateau. This points to a concentration on supply and distribution from Stromlo for the Molonglo Valley and Googong for the Kowen Plateau.

Also of significance is that the current southern extremity of urban development is not likely to be extended. When Canberra was growing rapidly towards Tharwa, the Tennent water supply was preferred because of its location. It has now lost that relative advantage.

The report *ACT Government, November 2003, Shaping Our Territory. Final Report:* Opportunities for Non-Urban ACT, concludes, amongst other things, that:
the land within the Cotter catchment should be managed primarily with the objective of maximising water quality;
as a first priority, revegetation of riparian zones with native species should occur;
also as a first priority, the forest road network should be rationalised and upgraded with the objective of preventing sediment flows into streams and the Cotter Dam; and
recreational activities within catchment areas should be managed consistent with water quality objectives.

The *Draft Canberra Spatial Plan* (Section 2.1, "Our People") describes population growth and demographic change. It says:

> *A strength of the Canberra Spatial Plan is that it will provide a framework within which variable growth rates, from 430,000 to 500,000 and beyond can be accommodated in a sustainable manner. With the high case scenario of the ABS population projection for the ACT, population is expected to reach approximately 460,000 in 2032, while the ACT Government population projection for the high case scenario predicts 440,000 people for the same year. Whether this growth occurs within the timeframe of the Spatial Plan does not affect the overall approach to managing the change necessary to achieve the vision for Canberra as a sustainable city.*

Further on the Plan states (page 60) that

> *[recent] events and the strong urban growth within the region have highlighted the need to plan for water supply on a regional basis. In particular, the viability of potential development areas outside the ACT ……. is dependent on the availability of a potable water supply.*
>
> *The Territory will, through a range of strategies, defer as long as possible, the need for a new dam. However, with the continued development of the ACT and surrounding NSW, additional potable water supplies are expected to be required in the long term.*

Thus, Canberra's key planning document endorses the continued planning for the next supply, and assumes that planning will proceed taking regional growth into consideration.

When is a new water source required for the ACT?

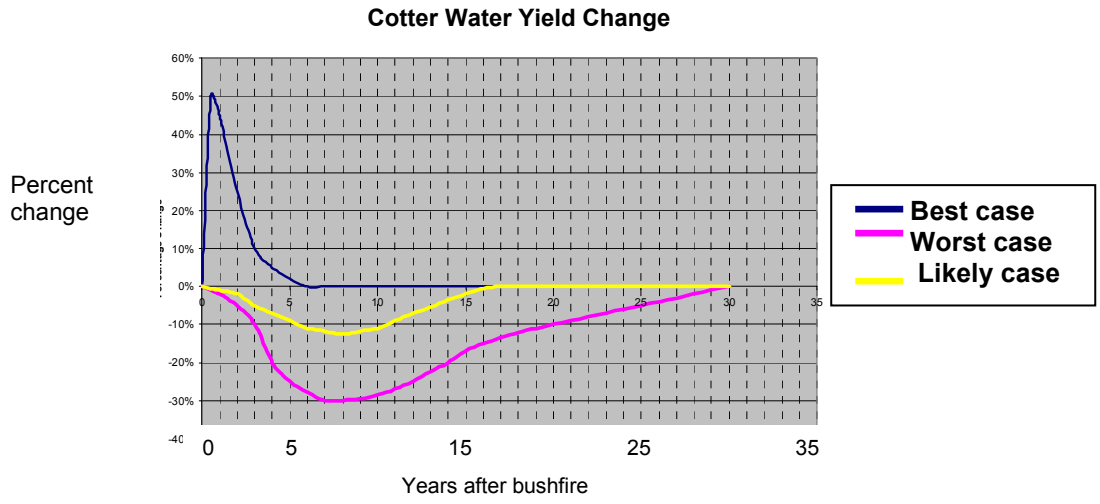
In the past, predicting when a new water source was needed for the ACT involved estimates of population growth, measuring existing water consumption patterns, current environmental flows and assuming no drought worse than previously recorded. This information was then modelled to predict the timing of a new supply based on the size of the population that could be served. The output from this model identified the need for a new water supply when ACT reached a population of 405,000, estimated to occur in 2017 (based on ABS predictions). There is now a need to re-examine these assumptions, as well as the modelling methodology, and include effects due to bushfires, climate change, climate variability, water consumption, the historical climate record (examining the worst drought on record) and possible water supply to NSW. The duration and frequency of water restrictions also needs further consideration. The ACT Government has set targets to reduce per capita consumption in the ACT's Water Resources Strategy. Meeting these targets will contribute to deferring the need for a new water source for the ACT.

Bushfire damage

On 18 January 2003, the ACT experienced an unprecedented fire disaster, which has major long-term consequences for the water resources of the ACT. In summary, the bushfires burnt all the Cotter water catchment (fire severity ranging from low to very high), scorched or destroyed 78 per cent of the canopy in the Bendora sub-catchment (fire damage ranging from high to very high) and damaged 42 per cent of the canopy in the Corin sub-catchment.

Water runoff: Investigations by Ecowise, and peer reviewed by the CRC for Catchment Hydrology, into the behaviour of the catchment over the past year indicate there has been little change in runoff patterns in the catchment. Preliminary assessments on the range of catchment responses with respect to the amount of water likely to runoff are shown below. The future response of the catchments to the bushfires is still uncertain and Ecowise is carrying out further research.

Figure 4: Cotter water yield change



Long-term climate change

Work has been done by CSIRO and the CRC for Catchment Hydrology on climate change projections and the impact on water availability for the ACT region. There are uncertainties in these projections. The following is the best available thinking on key topics:

Temperature change: Projections indicate that the mean annual temperature could increase by 0.4ºC to 1.5ºC by 2030 and about 1.0ºC to 4.8ºC by 2070. Increases in temperature will lead to changes in the frequency of extreme temperatures in the ACT Region.

Rainfall change: By 2030, projections for average annual rainfall range from an increase of 2 per cent to a decrease of 9 per cent, and by 2070 from an increase of 7 per cent to a decrease of 29 per cent. Models also indicate an increase in the frequency and intensity of extreme rainfall under climate change condition.

Evaporation change: By 2030, annual evaporation is projected to increase by 1.4 per cent to 9.1 per cent.

Temporal shift: In the 1970s a sudden shift in climate saw runoff from water supply catchments in the southwest of Western Australia reduce significantly. It is possible that the climate in the ACT region could shift in a short period to a new state; also producing reduced runoff from our catchments.

Increases in temperatures are likely to result in increased evaporation, meaning more water use within the ACT. During wet years, rainfall effectiveness would be reduced by higher evaporation associated with higher temperatures. Under these circumstances it is predicted that a 10 per cent reduction in rainfall and changing rainfall patterns would result in a reduction of runoff into the dams up to 20 per cent.

Further, CSIRO suggest there is some evidence the ACT has already experienced some level of climate change. Analysis suggests patterns of atmospheric circulation over the Murrumbidgee Basin have changed over the last 40 years, with weak evidence for a decline in rainfall over the ACT region, a decline in inter-annual variability since the 1980s and a change in rainfall seasonality (increased winter and decreased summer rainfall).

Climate variability

The ACT has a variable climate. The need for large dams, in the overall Australian context, is due to climate variability and the requirement to secure water for consumptive use either in cities or for rural and industrial endeavours. It is the periods of drought that determine how much water we need to store to ensure that sufficient water is available until rainfall again replenishes the storages. The current drought is requiring many water utilities to re-examine and often down grade current estimates of water yield. This means that many cities now do not have as much water available in times of drought that they previously thought. In addition, when assessing options for a new water source for the ACT, consideration will be given to climate variability within and between various catchments. In the areas surrounding the ACT, it is known that catchments to the west (ie the Tantangara catchment) has a higher and more reliable rainfall than the Cotter catchment which also has a higher and more reliable rainfall than the Googong catchment. Work undertaken by CSIRO Sustainable Ecosystems suggest that tools are now emerging for better climate forecasting at varying time scales to enable a more efficient use of existing water supplies.

Water efficiency program

The Government has set a target of a 12 per cent reduction in water use by 2013. ACTEW is working with the Institute of Sustainable Futures at the University of Technology, Sydney to develop this program. By using water more efficiently in the ACT the need for a new water

source can be deferred. The success of the program is dependent on the residents, business and governments adopting water efficiency measures.

Population Served

The population to be served from the ACT's water supplies is also a factor in determining when a new supplied may be required. A higher growth in population, such as that suggested in the ACT Spatial Plan, would bring forward the timing of a new supply. Similarly, if a decision were made to supply water beyond the current residents in greater Queanbeyan to surrounding townships and further areas of growth in NSW then this also would bring forward the timing for a new supply. Population predictions are derived from the ACT Demographer and the Australian Bureau of Statistics.

When is a new water source required?

Modelling that was completed in the recent past suggests that a new supply would be required by 2017 at the latest. However, more recent analysis suggests that a reduction in potable water use of 12 per cent may be offset by the reduction of inflow to the dams as a consequence of the bushfires. Climate change may result in further reductions to dam inflows. Higher population growth, bigger droughts than those previously experienced and the desire by Canberra's residents to avoid Stage 3 water restrictions together indicate the timing for a new supply may be bought forward. This is a critical and complex piece of planning is yet to be completed. As outlined in the Government's Water Resources Strategy, a more definite estimate of the timing of a new water source for the ACT will be delivered by December 2004.

How far ahead do we need to plan for a new water supply?

The development of a new water supply source requires a relatively long lead time. It would normally require:

- two and a half years for the planning and environmental impact studies;
- five and a half years for the design work, including all detailed site investigations; and
- two years for construction.

If the next supply is a dam, then depending on the type of dam design used and the climatic conditions at the commencement of the filling period, it may take a further one-two years for the dam to reach full storage capacity and for the water to reach an acceptable quality.

For a new dam on an unregulated river (eg Tennent dam), work generally needs to commence ten to twelve years prior to the supply being required. Other options can be expected to be delivered more quickly. For example, raising an existing dam (eg Cotter Dam) would likely require less planning approval, and generally less infrastructure construction. Whereas, a transfer of water from interstate (eg the Tantangara transfer option) would require considerable negotiation with other governments and interested parties as well as the necessary construction and environmental assessments.

DROUGHT CONTINGENCY PLANNING

The ACT has experienced significant droughts in the past. The worst drought on record occurred in the period 1939 to 1945 and this is the drought that is used in planning the need for future water supplies in the ACT. That is, modelling relies on the fact that the ACT is able to cope with a drought of this magnitude. The next most serious drought is that of 1979 to 1983. This drought was much shorter, but Canberra's water supply almost became critical in 1983. The current drought is believed to be as serious as that of 1939 to 1945. If this drought were to continue it would be the worst drought ever experienced in the ACT and a situation for which has not been planned. In April 2004, dam levels were about 50 per cent and falling due to the

extraordinarily dry autumn in 2004. Therefore, ACTEW are developing contingency plans in the event of the continuation of this dry spell. These are summarised below.

The construction of a new water treatment plant at Mt Stromlo, as a result of the recent bushfires, mean that it is now once again practical to utilise the Lower Cotter Dam as a component of the ACT's water supply system. Plans are being developed to incorporate the Lower Cotter Dam later in 2004 to augment the existing supply and relieve pressure on the current dwindling water resources. If rain does not fall over the next few months, however, it is unlikely that this will be sufficient to defer the needs for Stage 3 restrictions, and perhaps Stages 4 and 5.

The next step being investigated is to pump water from the Murrumbidgee River. This would be a repeat of the situation in 1968, when pumps were installed in the Murrumbidgee River near the Cotter pump station and water was pumped into Cotter Dam. This water would then be treated at the new Stromlo water treatment plant, before being delivered to customers. This Murrumbidgee River option includes either using the natural flow in the river, or supplementing it by releasing water from Tantangara Dam. In 1968 water was released from Tantangara and 1.3 million kilolitres of water was pumped into Canberra from the Murrumbidgee. If the ACT is to examine this option, discussion are needed with the NSW Government, Snowy Hydro and other interested parties.

This contingency plan is being developed in the event of a continuation of the drought for the remainder of 2004, and beyond. Such a drought would be unprecedented in Canberra's history. Given, however, the essential requirements of water to the ACT, ACTEW are developing contingency plans for such an event to ensure the security of the ACT's water supply.

CHOOSING A NEW SUPPLY

Factors to be considered

Complex factors need to be considered in any investigation of water supply options. Following is an outline of the major factors to be considered.

Environmental impact

Should a new water supply be needed there are environmental issues at each critical stage (site location, construction and operation) that need to be weighted against one another. For example, if choosing between a gravity tunnel and a pump/pipeline scheme, the 'costs' of disruption during construction of the gravity tunnel need to be considered against the costs of greenhouse gases a pump/pipe system would produce during its life.
Such detailed environmental considerations are not covered in this report but will be considered in the detailed analysis of the recommended options.

Water quality

The quality of the water supplied from any new source determines the type and capacity of the treatment facilities required. This, in turn, dictates the cost of treatment, and the risk of contamination.

Yield

Yield is generally defined as the maximum constant demand that a water source can provide without running empty, based on inflows that are either historically measured or artificially generated. The crucial determinant of yield is the ability to supply water through a drought.

The total yield of a system is greater than the sum of the yields of each dam in the system. Whilst yield is a good measure of the ability of a single source to supply water, better than (for example) dam volume, it requires an understanding of the calculation method to allow comparison. For this report a common method has been used for all options, not as a definitive statement on the yield of each but as a way of comparing how much water we might expect from each option. Definitive statements on yield will be included in the further investigation of the recommended options, taking into account factors such as climate change, bushfire impact and the uncertainty of the ACT's relatively short (90 years) rainfall records.

Yields presented in this report are based on a dam's ability to cope with our 90 years of historic streamflows. They have been calculated by running historic inflow and consumption information with different populations, and determining what population would cause the total storage to run empty. It must be stressed this is not an operational plan, but simply a way of comparing the value of one storage against another.

For example, when comparing a dam in a high rainfall area with one in a lower rainfall area, the former does not need to be as big as the latter because the more frequent rain will top it up. In the ACT, Googong Dam represents 60 per cent of our total storage but because it has less rain than the Cotter it is only capable of providing about 40 per cent of the yield long-term. This reflects the general nature of the catchments around the ACT; those to the west eg the Tantangara catchment have a higher and more relatable rainfall than the Cotter catchment, which also has a higher and more reliable rainfall than the Googong catchment. These differences in catchment characteristics also need to be considered when choosing a new water source for the ACT.

Operating costs

In general the cost of operating a new supply is based on the amount of water used from that supply, the extent to which it has to be pumped, the water quality and, if applicable, the cost of that water.

In this report the costs of treatment and pumping have been estimated, as has the cost of purchasing water. However, as these costs are subject to the market forces of supply and demand, the estimate is only as good as our ability to predict what will happen in the water market into the future.

Predicting how much water will be used from a particular source is the most difficult. Influencing factors will include future population trends, usage, weather, the effects of the bushfires and climate (including climate change). In order to develop a comparative basis, operating costs in this report have assumed average per capita demands for all future years (ie total demand rises with population).

Capital cost

The staging of capital costs is important in economic terms, and this is discussed in the next section on population growth.

Population growth and ceiling

The sequencing of future water supplies is as important as determining the next supply.

For example, if the ACT chooses an enlarged Cotter Dam as its next supply, and if population growth accelerated (eg. a very fast train project was developed) then an additional new source might be required. However, if the Tennent option had been chosen, the chances of needing a new source would be much less (ie. Tennent can supply more water than a raised Cotter dam). Hence the choice of options requires knowledge of the population growth rate in the ACT. The current regional population predictions prepared by the ACT Demographer reach a maximum

of 460,000 in around 2050, thereafter declining. By contrast the *Draft Canberra Spatial Plan* adopts a high growth scenario of 500,000 people by 2032.

Distance from existing infrastructure

The distance of the supply from Stromlo, Googong or our bulk supply mains impacts on the length and therefore cost of the pipelines and pumping stations needed to deliver the water for treatment and/or distribution. The Tennent site suffers most from this constraint.

The ground and geological conditions

At dam sites or for pipelines, the geology will determine the type of construction. Poor ground conditions may require more expensive construction techniques or even make sites unsuitable. Good (hard) ground conditions are difficult for laying pipelines. Detailed information on ground conditions has not been collected for all options at this stage.

Height/storage curve

The amount of storage that can be gained from a metre of dam wall is critical to the economics of a dam. The shape of the height/storage curve for a potential dam site is a key determinant in the value of a site.

Hazard rating

Dams are rated on the likely consequences that may occur if the dam wall was to fail. Dams that are upstream of populated areas receive a higher rating and require a more conservative approach to dam safety and construction.

This favours dams on the Cotter River over the Molonglo or Queanbeyan rivers.

Cotter bushfires

The bushfires are likely to reduce the yield of the ACT's existing dams on the Cotter River, and bring forward the date for a new supply. The full extent to which yield will be reduced is still being determined, however initial estimates suggest that it is likely the yield will be reduced over the next 15 years. In terms of the next supply, this notionally affects the yield of the Tennent, Coree and lower Cotter dams. This issue, however, will be considered in more depth as part the detailed planning for the shortlisted options.

SHORTLISTED OPTIONS FOR NEW ACT SUPPLY

A three-stage approach

This report summarises a three-staged approach to identifying Canberra-Queanbeyan's next water supply source.

Stage 1	Preliminary investigation of nearly 30 possible options.
Stage 2	Eleven options based on four water sources underwent more detailed analysis.
Stage 3	Recommendations of options for detailed evaluation.

Stage 1 – preliminary investigations

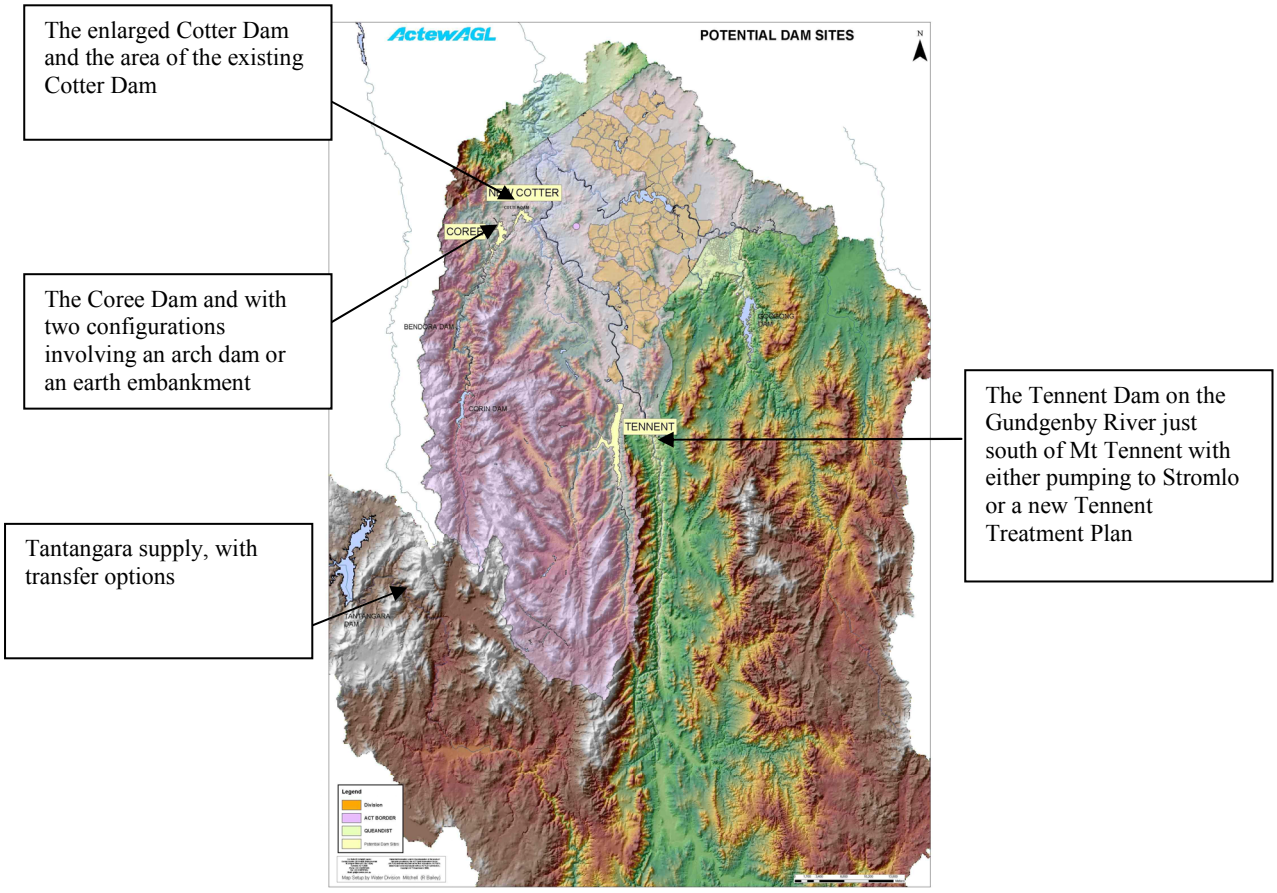
The Stage 1 preliminary investigations primarily involved financial and hydrological modelling and reviewing previous relevant studies and reports, in light of the current day situation and future planning scenarios. See Appendix A for those options that were discounted at the end of Stage 1.

Although further detailed engineering investigations would be required to confirm their viability, each option that has been considered in Stage 2 passed the initial feasibility test.

It should be noted, however, that this initial test did not attempt to quantify the environmental costs. Measuring and balancing environmental (eg. land use, greenhouse etc), social and economic costs and benefits is recognised as a key determinant in choosing the next supply. It will be considered during in-depth future analysis of the options recommended for further investigation.

Stage 2 – preliminary costings of the shortlisted options

Figure 5: Site plan of shortlisted options



In addition to the analysis in Stage 1, detailed preliminary cost estimates were made in Stage 2 of each of the shortlisted sources.

These estimates have the status of "pre-feasibility" estimates. They are based on studies of the options, and 2003 estimates of the costs of pipelines, excavation etc. They do not include comprehensive environmental, social and economic cost:benefit analysis. This will require significantly more work, including independent assessment, before a final option can be recommended. In addition, each option represents a different source yield and hence level of security of water supply. Quantifying this level of security is not within the scope of this report as it involves statistical analysis of relevant historical and simulated data, with allowance for bushfires, climate change, population growth etc. The level of security required will drive the timing of the next dam, but will not change the comparative capital and operational costs.

The work undertaken in the Stage 2 assessment has helped to reach a recommended list of three possible supply options for further investigation by assessing the known characteristics of each option and how this might affect viability against some common benchmarks.

Table 1 Physical characteristics of shortlisted options

Supply Option		Top Water Level		Capacity (GL)		Height		Treatment required?	Yield (GL[3])
		Old	New	Old	New	Old	New		
Enlarged Cotter									
Supply to Stromlo		**505**	**550**	**4.7**	**78**	**31**	**88**	**Yes**	**17.0**
Tennent									
Supply to Stromlo		**-**	**655**	**-**	**152**		**76**	**Yes**	**32.0**
Supply to Tuggeranong		**-**	**655**	**-**	**152**		**76**	**Yes**	**32.0**
Tantangara									
Pump to Cotter River		**-**	**-**	**-**	**-**	**-**	**-**	**No**	**25.0**[4]
Tunnel		**-**	**-**	**-**	**-**	**-**	**-**	**No**	**25.0**
Yaouk Valley to Porcupine Creek		**-**	**-**	**-**	**-**	**-**	**-**	**No**	**25.0**
Yaouk Valley gravity pipeline		**-**	**-**	**-**	**-**	**-**	**-**	**No**	**25.0**
Coree									
Coree Arch	To Bendora Gravity Main	**-**	**618**	**-**	**68**	**-**	**79**	**No**	**15.1**
Coree Arch	To Coree Gravity Main	**-**	**618**	**-**	**68**	**-**	**79**	**No**	**15.1**
Coree Embankment	To Bendora Gravity Main	**-**	**625**	**-**	**86**	**-**	**88**	**No**	**17.0**
Coree Embankment	To Coree Gravity Main	**-**	**625**	**-**	**86**	**-**	**88**	**No**	**17.0**

Capital and operating costs

Table 2 summarises the capital costs of the shortlisted options. It needs to be noted that the capital cost of the Tantangara option is heavily dependent on the volume of water purchased in the water licence, and the staging of those purchases. For example, if the ACT was to purchase a 50 Gigalitres licence, a similar amount to the storage options, then the capital cost would rise by another $37.5m. However, it may be possible for the ACT to sell the water not required for use in the ACT and so significantly offset this cost. Each option, and hence capital cost, represents a different level of security (source yield).

Table 3 summarises the operating costs of the shortlisted options. In order to gain an understanding of the relative ranking of each option (but NOT the timing of a new supply), certain assumptions have been made to allow Net Present Value of each option to be calculated. These assumptions include that:

- all years from now will be average consumption years;
- demand grows linearly with consumption; and
- the average production from the Cotter system will be capped at the average production levels in the year of the new supply.

It must be stressed that it is known that these assumptions are not precise, but they have allowed a ranking of options. Note the costs per kilolitre (kL) compared to the price of water, currently over $1.00/kL.

[3] See page 9, Yield

[4] "Assumed yield" – is whatever water right is purchased, and that allocation will always equal purchased right.

Table 2 Capital costs of shortlisted options

Supply Option		Dam ($M)	Pipe ($M)	Pump Stn ($M)	Storage ($M)	Water treatment plant ($M)	Water Licence[5] ($M)	Total ($M)	$M/ GL yield
Enlarged Cotter									
Supply to Stromlo		**93.0**	**2.7**	**6.9**	**-**	**-**	**-**	**102.6**	**6.0**
Tennent									
Supply to Stromlo		**80.0**	**46.0**	**4.6**	**-**	**-**	**-**	**131.0**	**4.1**
Supply to Tuggeranong		**80.0**	**18.9**	**5.1**	**6.3**	**20.0**	**-**	**130.3**	**4.1**
Tantangara									
Pump to Cotter River		**5.0**	**39.0**	**12.5**	**-**	**-**	**37.5**	**94.2**	**3.8**
Tunnel		**10.0**	**60.0**	**-**	**-**	**-**	**37.5**	**107.5**	**4.3**
Yaouk Valley to Porcupine Creek		**10.0**	**14.0**	**6.2**	**-**	**-**	**37.5**	**67.7**	**2.7**
Yaouk Valley gravity pipeline		**5.0**	**74.7**				**37.5**	**117.2**	**4.7**
Coree									
Coree Arch	To Bendora Gravity Main	**94.0**	**2.4**	**5.4**	**-**	**-**	**-**	**101.8**	**6.8**
Coree Arch	To Coree Gravity Main	**94.0**	**22.4**	**5.4**	**5.0**	**-**	**-**	**126.8**	**8.4**
Coree Embankment	To Bendora Gravity Main	**121.0**	**2.4**	**5.4**	**-**	**-**	**-**	**128.8**	**7.6**
Coree Embankment	To Coree Gravity Main	**121.0**	**22.4**	**5.4**	**5.0**	**-**	**-**	**153.8**	**9.1**

Table 3 Operating costs of shortlisted options ($/kL)

Supply Option		Pumping	Treatment	SMHEA payments	Water purchase	Total
Enlarged Cotter						
Supply to Stromlo		**0.090**	**0.050**			**0.140**
Tennent						
Supply to Stromlo		**0.042**	**0.050**			**0.092**
Supply to Tuggeranong		**0.053**	**0.050**			**0.103**
Tantangara – 50 GL						
Pump to Cotter River		**0.15**	**0**	**0.06**	**0.028**	**0.236**
Tunnel		**0**	**0**	**0.06**	**0.028**	**0.087**
Yaouk Valley to Porcupine Creek		**0.074**	**0**	**0.06**	**0.028**	**0.157**
Yaouk Valley gravity pipeline		**0**	**0**	**0.06**	**0.028**	**0.087**
Coree						
Coree Arch	To Bendora Gravity Main	**0.058**	**0**			**0.058**
Coree Arch	To Coree Gravity Main	**0.058**	**0**			**0.058**
Coree Embankment	To Bendora Gravity Main	**0.058**	**0**			**0.058**
Coree Embankment	To Coree Gravity Main	**0.058**	**0**			**0.058**

[5] Note, these costs have been spread out over the 50 year period of the assessment, with 25GL bought at the notional start date for the new supply and another 25GL in 25 years time. The second purchase has no economic impact because it is so far into the future.

It needs also to be noted that it is known that demand will vary from year to year, with underlying trends due to climate change, demand reduction, block size etc. Using average demand figures masks all of these significant effects. The averaging of operating costs, however, is a valid technique for ranking the relative merits of each option.

Net Present Values

The Net Present Values (NPVs) of the operating and capital costs have been calculated using the capital and operating costs and the assumptions set out above. In addition the following assumptions have been made:

- The notional start date for the next source is 2017. To meet this date significant expenditure would be required from 2012. Hence, the NPV has been expressed in 2012 dollars. (This is equivalent to saying how much money would be needed in the bank in 2012 in order to fund each scheme for its economic life.)
- Allowance has been made to expend capital costs over likely constructions times, and to allow time for dams to fill etc.
- A discount rate of 7.7 per cent has been used.

A review of each of the shortlisted options

Following is a review of the shortlisted options.

Enlarged Cotter

The Cotter Dam could be enlarged, by building a roller-compacted concrete, gravity dam. Incorporating the old dam, it would have a height of 88 metres and a storage capacity of 78 Gigalitres.

Figure 6: Enlarged Cotter Dam Cross Section

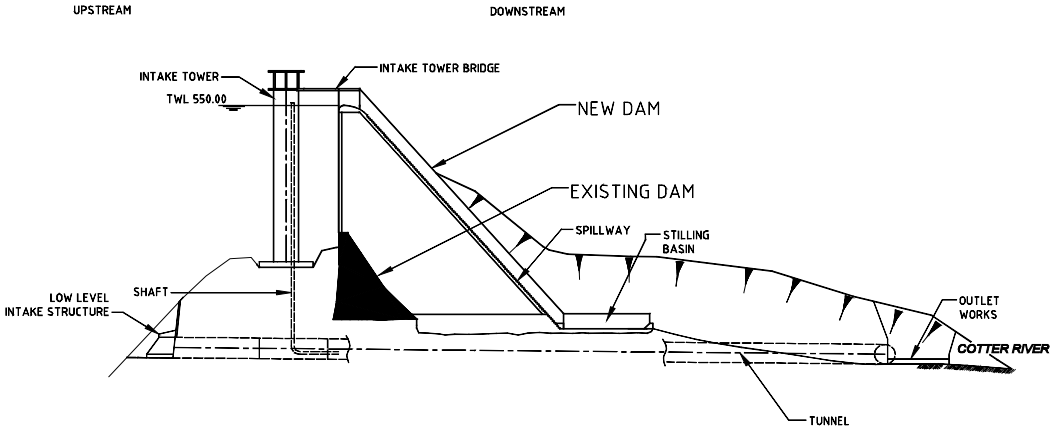
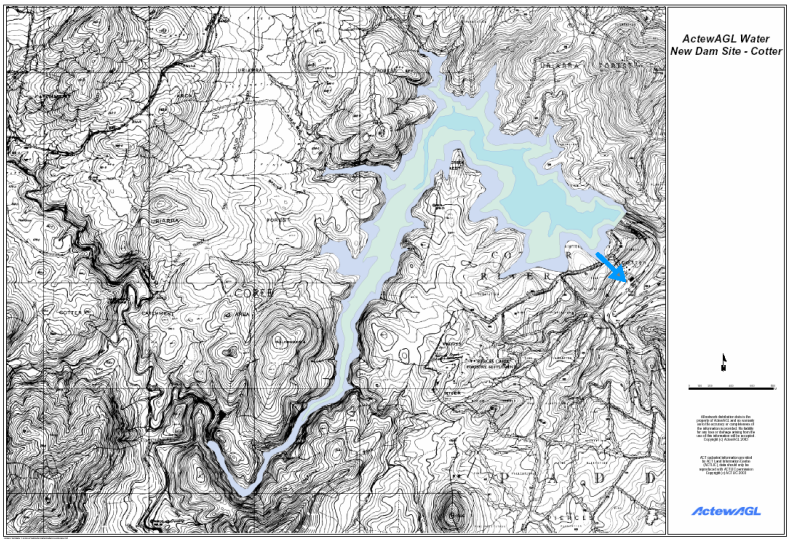


Figure 7: Area to be flooded by Enlarged Cotter Dam



The area to be flooded is indicated in Figure 7. The spillway for the new dam would be over the dam wall, in the same manner as the existing dam. The top water level of the stored water would be 550 metres, which is some 167 metres below the balance tank at Mt Stromlo. Water would be pumped from the new dam to Stromlo WTP in the same way as it is now.

Some refurbishment of the Cotter pump station would be required to meet the increased demand. A new pipe would be required from the dam to the Cotter pump station but no new delivery lines would be required from there to Stromlo WTP.

The water would require treatment at the new Stromlo filtration plant.

The National Capital Plan currently provides for the Lower Cotter Sub-catchment to maintain water quality to at least existing conditions in the short term, with further consideration to be given to the longer term use.

GOOD TRAITS

- With full water treatment required subsequent to the bushfires, this dam has the potential to provide an additional water recreation area for the community, thus providing more community benefits from such an investment. It also fits well with the

theme for development of the Cotter area as set out in *ACT Government, November 2003, Shaping Our Territory. Final Report:* Opportunities for Non-Urban ACT

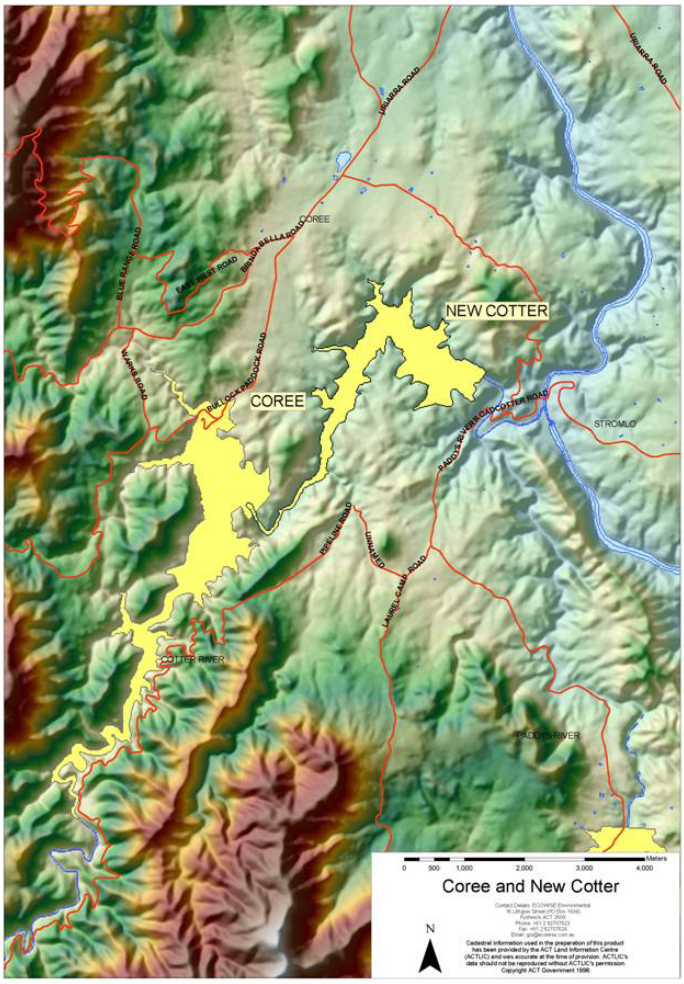
- Savings are possible because part of the existing water supply infrastructure (pipes, pump station and treatment plant) could be more effectively used.
- It involves enlarging an existing dam. Arguably, this would produce less environmental impact than the construction of a new dam.
- Almost all of the pine plantations within the Lower Cotter Catchment were destroyed in the January 2003 bushfire. Consequently, an opportunity exists for reafforestation that is more compatible with the potential water supply use of the catchment. This could improve water quality in the longer term. This issue is dealt with in the report *ACT Government, November 2003, Shaping Our Territory. Final Report:* Opportunities for Non-Urban ACT

BAD TRAITS

- The existing Cotter Dam, and its headwaters, contains significant populations of two spined Blackfish and Macquarie Perch. Protection of these species would require detailed management plans.
- Water quality of the Lower Cotter currently needs full treatment, as will any enlarged dam. Recreation on the dam would need careful management from a water quality perspective.
- Water from the enlarged Cotter Dam would have to be pumped up about 167 metres to the level of the Mt Stromlo balance tank. This would require a significantly higher energy input per megalitre compared to both the Bendora and Googong supplies.

Coree Dam

Figure 8: Coree Dam site



The National Capital Plan identifies Coree as an area to be considered for the construction of future water storage. Coree is just below the junction of the Cotter River and Condor Creek. While the National Capital Plan provides for the existing use to continue in the short term, it states that if a dam was constructed at Coree it should be on a basis that it requires water treatment by disinfection only. Hence if it was to become a reservoir for Canberra water supply it could not be used for any other purpose, such as recreational uses.

Two alternative options exist for the dam walls being:

- An earth and rock fill embankment. Two embankments would need to be constructed to achieve a storage with a volume of 86 Gigalitre and a top water level of 625 metres. The embankment would be 86 metres high.
- A concrete arch dam, around 79 metres high, with a reduced storage of 68 Gigalitre and a top water level of 618 metres.

With the reservoir closed to recreation and access limited to the catchment it is expected that the water quality would require only disinfection and fluoride treatment for the majority of the time. However, the January 2003 bushfires may mean it would require treatment for some period of time, depending on dam timing and catchment recovery.

Figure 9: Coree Embankment Dam

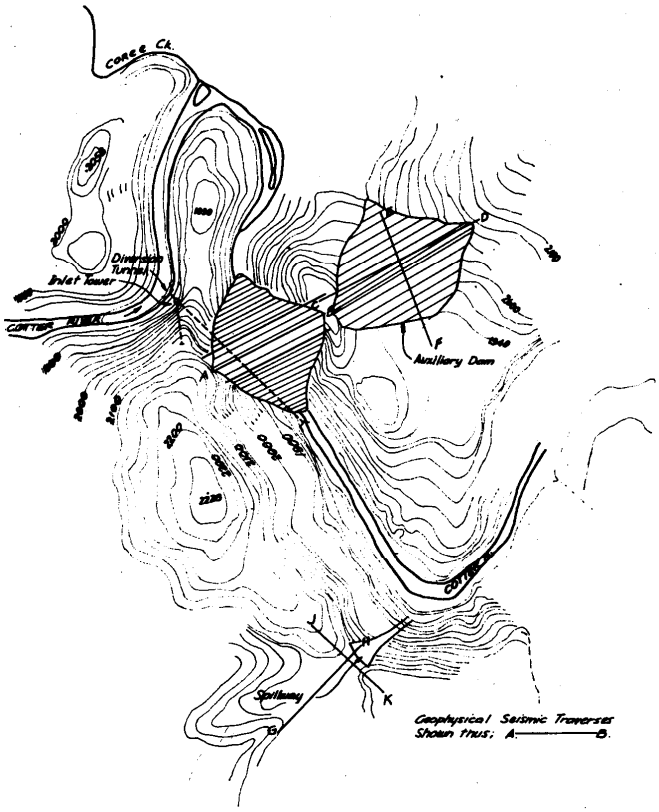


Figure 10 Coree Arch Dam

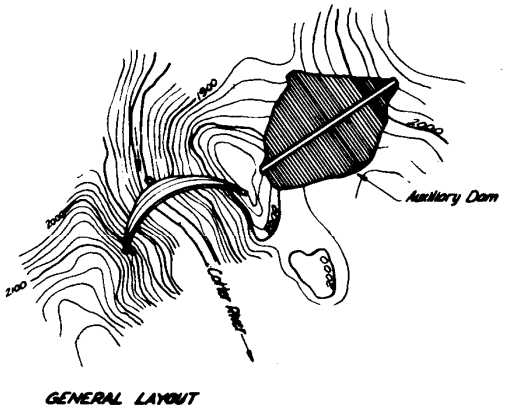
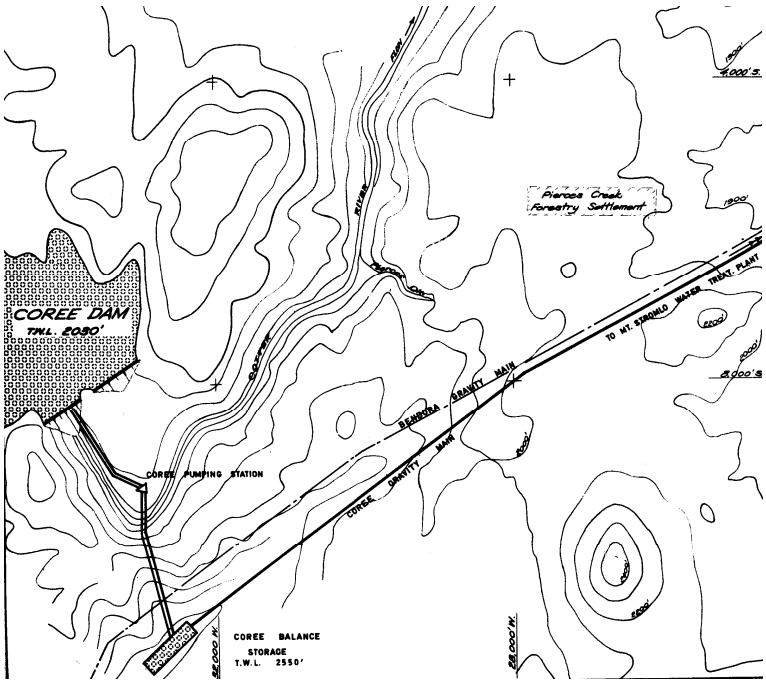


Figure 11: Coree Dam site layout



Two options exist for moving Coree water to Mt Stromlo. The first is letting it flow down the Cotter river to lower Cotter Dam, and pumping from there. This has the advantage of saving on infrastructure, but the disadvantage of potentially deteriorating the water quality by mixing the water with inferior Cotter water, hence making the 'shandy" require treatment. This option (Coree "run of river") is considered inferior to simply enlarging the Cotter Dam, primarily because an enlarged Cotter Dam would have the same pumping costs as this option, plus more catchment (ie. greater yield). Additionally, the bushfires (and proposed post bushfire land use policy) have removed the water quality advantage Coree had over Cotter. Accordingly, this option has not been costed in detail.

An alternate option would be to pump to a balancing reservoir on a hill near Coree, and gravitating to Stromlo from there. This could protect water quality but would require additional infrastructure. This option is shown in Figure 11.

GOOD TRAITS

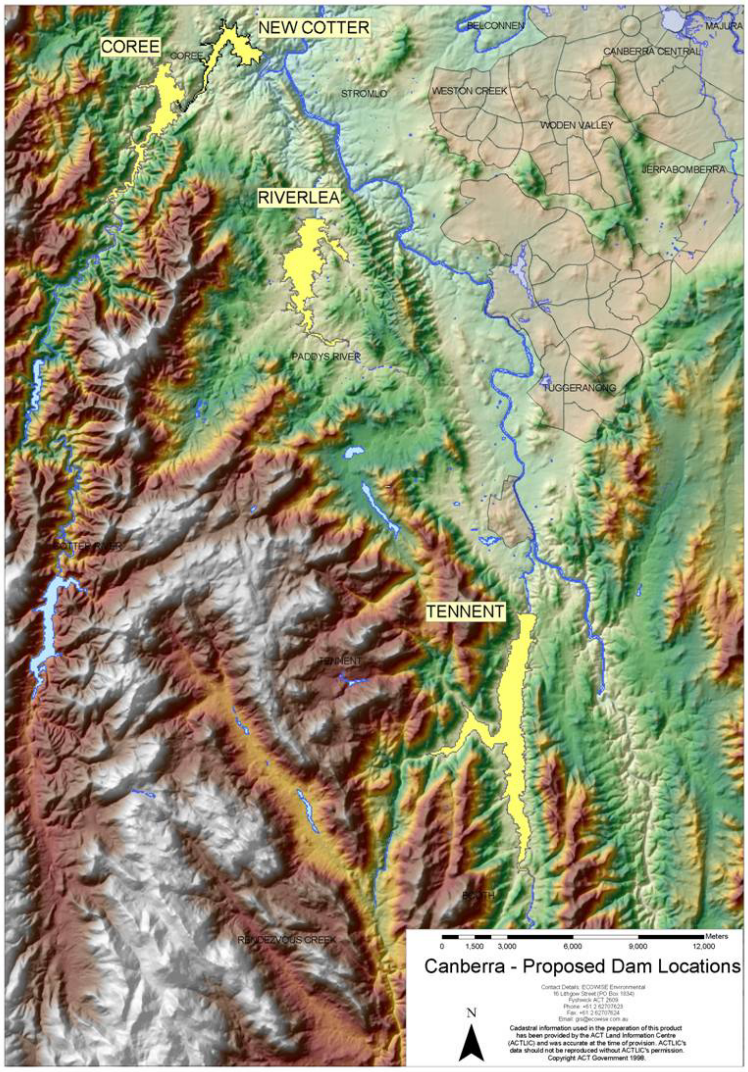
- Planning is consistent with the National Capital Plan, which should assist the planning approval process.
- Minimal water treatment would be required. For the most part it is assumed that only disinfection would be necessary. Some occasional problems with iron and manganese could be expected but it should be practical to provide the necessary treatment for this at the Mt Stromlo Water Treatment Plant.
- The dam site is relatively close to existing infrastructure. In this respect it is a better option than Tennent, but not as good as enlarging lower Cotter.
- The catchment is part of the protected forest area of the Namadgi National Park which should contribute to higher water quality.
- The amount of energy required to pump the water to Mt Stromlo would be similar to that required for Googong (ie. less than for the lower Cotter).

BAD TRAITS

- The length of river between Cotter and Bendora contains significant populations of two spined Blackfish and Macquarie Perch. Protection of these two species would be important.
- New access road and power supplies would be required to the site from the Pierces Creek Forestry Settlement.
- New pipeline, pump station and balancing reservoir may be required.

Tennent Dam

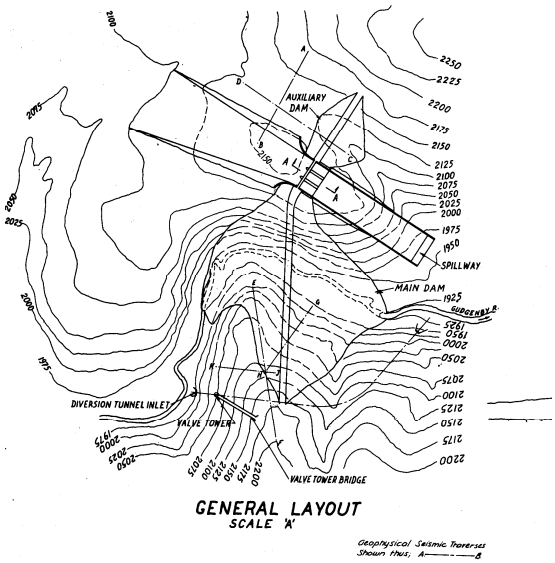
Figure 12: Tennent Dam site



The Tennent Dam site has been long recognised as a potential water supply for Canberra. This was particularly so when the greater expansion of Tuggeranong and the development of the Murrumbidgee West Bank was under consideration.

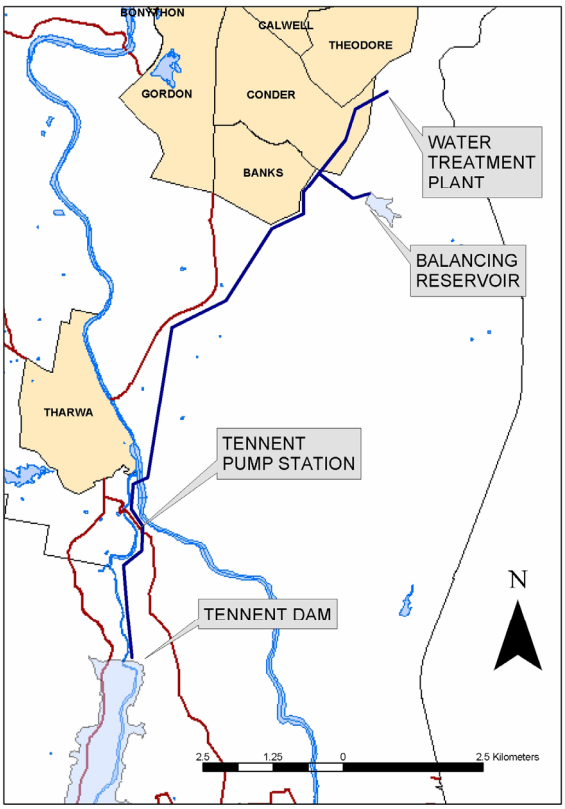
The dam site is in the Naas valley on the Gudgenby River just south of Mt Tennent. It is identified in the National Capital Plan as a site for a future reservoir for water supply and associated recreation. The National Capital Plan policy considers that approved grazing and pasture crop production should be allowed to continue in the short term but that the steeper and forested slopes on Mt Tennent and Billy Range should be progressively withdrawn from grazing and natural vegetation to be encouraged. The cleared slopes of the lower Naas and Gudgenby Valleys should be progressively revegetated by natural regeneration. Use of the future reservoir is to include public recreation, including fishing, rowing, sailing and low powered boats.

Figure 13 Tennent Dam layout



The dam would be constructed of an earth and rock fill embankment 76 metres high providing a water storage with a top water level of 655 metres and a storage capacity of 152 Gigalitres. It is anticipated that water from Tennent Dam would require full treatment, reflecting the agricultural use of the catchment, mainly grazing, over an extended period.

Figure 14: Tennent pump station, treatment plant and pipeline



There are two options to deliver Tennent water to consumers. Option 1 (Figure 14) involves a pump station at Tharwa, a balancing storage on the hill behind Banks, and a new water treatment plant on the hill behind Theodore. To avoid the new treatment plant, Option 2 involves a 29 kilometre pipeline of approximately 1600mm diameter and a pumping station to connect the dam with the Mt Stromlo treatment facility.

GOOD TRAITS

It is already identified in the National Capital Plan as a potential water supply dam.
It would provide very high yield.
It would provide a readily accessible water recreation resource for the southern suburbs of Canberra, although this would require management.
A third supply to Canberra would offer additional supply security.
The energy consumption for supply operation would be about equivalent to the current operation of the Googong supply.

BAD TRAITS

It would require the displacement of people from the Gudgenby and Naas valleys, and re-alignment and re-construction of the Naas and Boboyan roads.
Tennent is a long way away from the Stromlo treatment facility, meaning it would require its own water treatment plant or an expensive pipeline to Stromlo.
It is expected that the water would require full treatment because of farming operations in the catchment.
The stored water would significantly impact on the access to the southern part of the Namadgi National Park. New road construction would be required.
The Tennent catchment has a lower and less reliable rainfall than the Cotter catchment.

Staging – Gudgenby weir

The Tennent Dam option can be staged by the construction of a weir in the first instance.

This would involve building a weir and pump station at the site of the proposed Tennent Dam. Water would be pumped from the weir into Googong Dam at times of high flow in the Gudgenby River, supplementing the Googong storage. The pipeline would follow Angle Crossing Road, across the Monaro Highway and then Williamsdale Road toward Burra. The highest point is the pass between Mt Burra and Gilbraltar Hill, a level of 840 metres AHD (ie. higher that Bendora Dam). Consequently pumping costs would be high.

Tantangara

The Tantangara option envisages taking water from Tantangara Dam by tunnel and/or pipeline to the Cotter catchment. This option was first considered in 1963 in a report prepared for the National Capital Development Commission[6]. The proposal then was for gravity flow system, using a 60 inch concrete pipe following the Murrumbidgee River to Yaouk Flat, along the flat and finally through a short tunnel and into Porcupine creek. A similar option is proposed below.

In 1963 this option was rejected because

> *This scheme would involve the use of water not at present available to the ACT, therefore, in view of the large undeveloped resources in the ACT, and the lack of any economic advantage it is considered that this proposal does not warrant further consideration at present.*

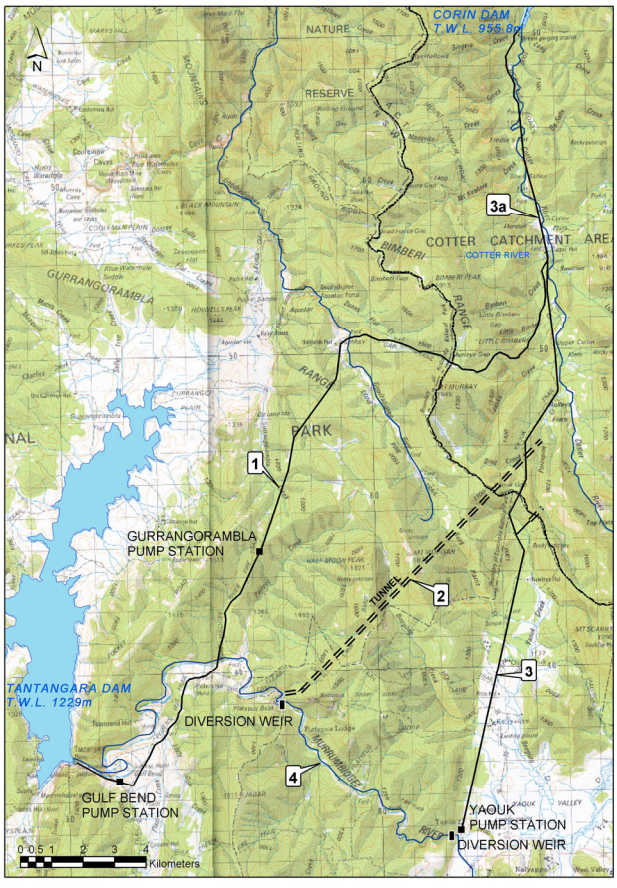
Whilst there are still undeveloped resources in the ACT, this project warrants re-examination because of its potential economic benefits.

It should also be noted that in the 1967/68 drought the Commonwealth purchased water and released it from Tantangara for the ACT. Temporary pumps were installed in the Murrumbidgee river, near Cotter pump station, and a temporary earth weir constructed downstream of the pumps. The water was pumped into Cotter Dam. There were enormous losses of water along the way, as might be expected, and very shortly after the exercise was completed the drought broke!

Figure 15: Tantangara pipeline routes

Since the ACT does not currently hold rights or entitlements to water in Tantangara's catchment, it would be necessary to purchase entitlements held by water users in NSW, Victoria or South Australia.

The Tantangara options involve purchasing the right up to about 50 Gigalitres of water under the Murray-Darling Basin Cap on water diversions. Four options to get Tantangara water into the Cotter catchment have been developed, namely:
Option 1 – water pumped through two pump stations and 30 km of pipeline across the Bimberi Range at Murray's Gap to discharge into the Cotter River upstream of Corin Dam.
Option 2 – water flows down the Murrumbidgee river to a diversion weir, then through a tunnel and discharge into Porcupine Creek, and then into the Cotter River.



6 Department of Capital Works, April 1963, *Report on Proposed New Storage Canberra Water Supply*

Option 3 – water flows down the Murrumbidgee river to a diversion weir at the Yaouk Valley from where it is pumped up the valley then through a short tunnel and into Porcupine Creek. Option 3a in the drawing shows the alternative of pumping all the way to Corin Dam. This option has been costed as an alternative in all cases.
Option 4 – using the same Yaouk Valley pipeline route as option 3, however this option also has a pipeline down the Murrumbidgee River, which would allow water to flow by gravity from Tantangara to Porcupine Creek.

In developing these options the following assumptions were made about the purchase and supply of water from Tantangara:
The ACT would purchase a licence for 25 Gigalitres in 2017, and an additional 25 Gigalitres 25 years later at a 2003 price of $1.5M/GL. These volumes were selected to make them comparable to the volumes available in the other options.
The ACT would purchase water at $28/ML each time it was required.
The ACT would pay $60/ML for forgone revenue in generating electricity.
Any opportunities to sell water entitlement in years when it was not required for the ACT have not been costed.

GOOD TRAITS
No new dam would be required, so the capital costs are lower.
No new dam also means a unregulated river valley would not be impacted.
There is potential to sell water allocation in years when it was not needed locally.

BAD TRAITS
Annual water allocation and pricing would be subject to market variations.
The option would have large operating costs due to pumping, water licence, forgone electricity revenue payments and water purchase costs.
The pipeline route would be difficult to access for maintenance, due to both remoteness and climatic conditions in this area.
Ownership or easement on the pipeline route and/or for pump stations might be an issue.
There would be environmental impact of inter-catchment transfer of water, and on the ecology of Porcupine Creek (which would have to cope with increased flows).
There would be environmental impact from building a pipeline and/or tunnel through this area.
For those options involving flow down the Murrumbidgee River there is potential for losses between Tantangara and the pipeline intake, and between the outlet and Corin reservoir.

Staging of these options
All options presented in this section of the report, except Tantangara, could be staged.

Coree, Cotter and Tennent all have the potential for the dam wall structure(s) to be designed for the ultimate height, but built to an intermediate level now, thus deferring some capital expenditure.

The benefits and costs of staging have not been developed in detail in this report, but will be considered in the Stage 3 phase of investigation. The potential for staging will be based on the potential for economic savings, and be driven by the rate of population growth.

Tennent appears to be the site where staging has the most potential to be a useful tool.

Tantangara could not be staged because it needs the entire pipeline connection to be workable. It is, however, of relatively low capital cost because no dam would be required.

Economic comparisons of the Stage 2 options

A great deal more analysis is required before an accurate assessment can be made of the best option for the next ACT water source. This includes detailed economic analysis. Table 4, however, summarises initial economic analysis of the options analysed at Stage 2. This work led to considering the 11 options from two perspectives:

- the price (Net Present Value) of providing water from each source in 2017, based on 2012 costs – this assumes major expenditure would need to start in 2012 in order to have the source available by 2017; and
- the cost per Gigalitre of water yield from each source.

Coree options are marginally attractive. However, Coree and an enlarged Cotter Dam are mutually exclusive (ie. once one is built the other would never be built) as their catchments overlap. Other factors also more strongly favour the Cotter Dam. These include that it has greater catchment and hence more yield, and it has less environmental issues. While Coree had better water quality than lower Cotter prior to the bushfires, this is not such a strong factor now that a large water treatment plant is being built at Stromlo. On balance, it is hard to see a case for continued examination of the Coree site.

Table 4 Summary of Capital, NPV and $M/GL yield costs

Option	Total Capital Expenditure $ (2012) Million	Net Present Value in 2012 for a supply in 2017[7]	Cost per GL of Yield	
		$ Million	$M/GL	Rank
Enlarged Cotter – Stromlo	**102.6**	**91.7**	**5.4**	**7**
Tennent- Stromlo	**131.0**	**125.4**	**3.9**	**4**
Tennent- Tuggeranong	**130.3**	**125.3**	**3.9**	**4**
Tantangara - pumped	**94.2**	**87.4**	**3.5**	**2**
Tantangara – tunnel	**107.5**	**90.4**	**3.6**	**3**
Tantangara – Yaouk Valley to Porcupine Creek	**67.7**	**64.0**	**2.6**	**1**
Tantangara - Yaouk Valley gravity pipeline	**117.2**	**97.6**	**3.9**	**4**
Coree Arch - To Bendora Gravity Main	**101.8**	**98.6**	**6.5**	**8**
Coree Arch - To Coree Gravity Main	**126.8**	**122.2**	**8.1**	**10**
Coree Embankment - To Bendora Gravity Main	**128.8**	**124.0**	**7.3**	**9**
Coree Embankment - To Coree Gravity Main	**153.8**	**145.5**	**8.6**	**11**

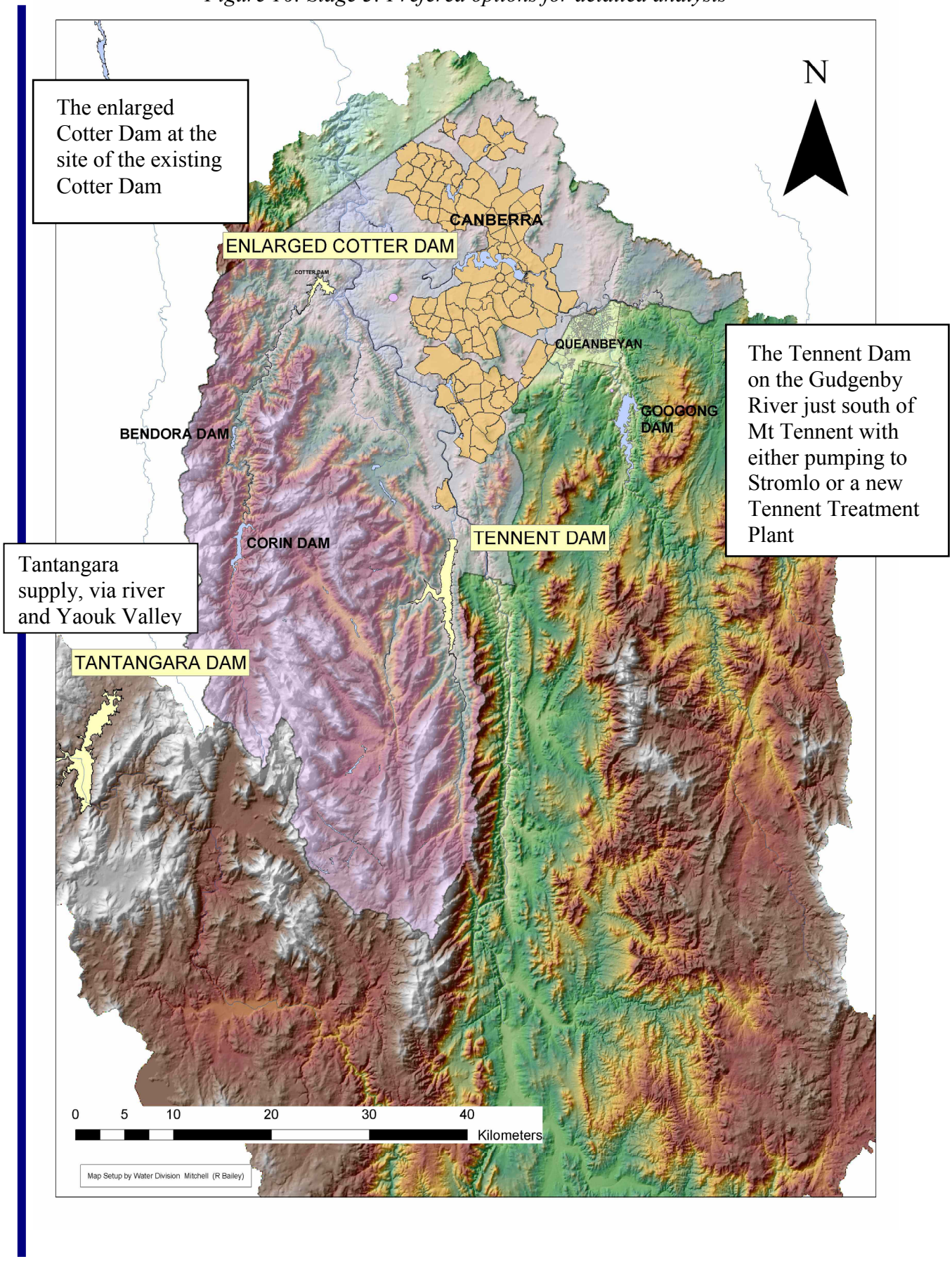
[7] Note for a dam in 2017 we have assumed expenditure on construction would start in 2012.

Stage 3 – options recommended for more detailed evaluation

The following options are recommended for more detailed evaluation:

1. Whilst **Tennent Dam** has a large capital cost, it would provide significant storage and the options of feeding water to either a new water treatment plant at Tuggeranong or to the new Stromlo treatment plant.
2. **Enlarging Cotter Dam** also has a number of advantages that should be examined in detail. These include its gravity feed nature, that it is an existing dam which would be enlarged, it is in a high rainfall catchment area and the river is already regulated.
3. The **Tantangara option** is attractive enough to warrant further investigation. From an engineering perspective the Yaouk Valley pipeline route, discharging into Porcupine Creek, should be examined in more detail. The other three pipeline options could be discarded because of their high operating cost (pumped option) or capital cost (tunnel option), but further examination of the social and environmental factors need to be considered.

Figure 16: Stage 3: Prefered options for detailed analysis



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APPENDIX A: OPTIONS NOT SHORTLISTED

The Stage 1 preliminary investigations led to a number of possible supply options for the ACT not being considered further. Following is a summary of those options.

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 Mt 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 45ML/d and 90ML/d. 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 45ML/day facility and $150m for a 90ML/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 was excluded after Stage 1 investigations because of the high cost, the perceived health risks and likely lack of public acceptance associated with such an option.

Cross Border Supplies

Many options were investigated in a preliminary way such as transferring water from the Snowy Mountains, 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[8]

Other than the Tantangara Dam to the Cotter system, which is recommended for further investigation, all the other options had 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 shortlisted options.

Groundwater

Groundwater use is allocated for each sub-catchment included in the *Water Resources Management Plan* under the *Water Resources Act 1998*. No further allocations are made beyond the sub-catchment limits unless specific studies on a particular catchment show that allocations can be increased without environmental harm or impact on other users.

Groundwater resources in the ACT are small by comparison with other parts of Australia, so small they cannot be considered as an alternative urban water supply source. While it may have some benefits on a small, localised scale, groundwater supply did not make the shortlist.

[8] Snowy Mountains Hydro-electric Authority, August 1968, *Augmentation of Canberra Water Supply Proposals to Utilise the Murrumbidgee and Goodradigbee Rivers,* for the National Capital Development Commission

Stormwater reuse

Traditional urban catchments are designed to encourage rapid runoff and quick removal of runoff through pipes and concrete drains to lakes and ponds. Water is not allowed to pool on urban surfaces, there is less infiltration into the soil and evaporation is substantially reduced.

All this means that more water reaches rivers from urban catchments than would have under previous rural or natural conditions. In Canberra's case, urban areas are thought to produce on average about 13 Gigalitres more runoff than the previous largely rural environment. Additionally, stormwater can contain high level of pollutants such as nitrogen, phosphorus, salinity, and bacteria.

Turning stormwater into a resource would not only reduce the impact of stormwater but also supplement mains water supply.

The re-use of urban stormwater, either on a domestic scale (rainwater tanks) or a neighbourhood scale, has not been considered in this report. It is considered a demand management (source substitution) option which may well be beneficial and may have a role in deferring the next supply.

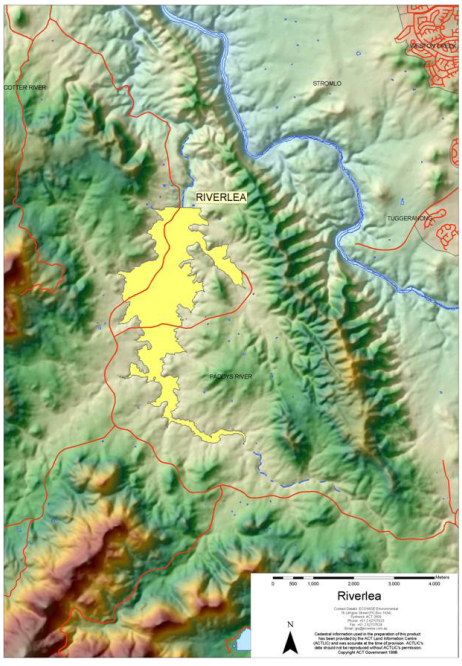
Riverlea Dam

A potential site for a water supply dam exists on Paddys River south west of Black Hill. The location of the dam is shown in Figure 17. 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.

Figure 17: Riverlea Dam site



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.
The dam site would require a long dam embankment (ie. more cost per GL stored) making it less attractive than other options.

Given these constraints Riverlea Dam has not been shortlisted.

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.

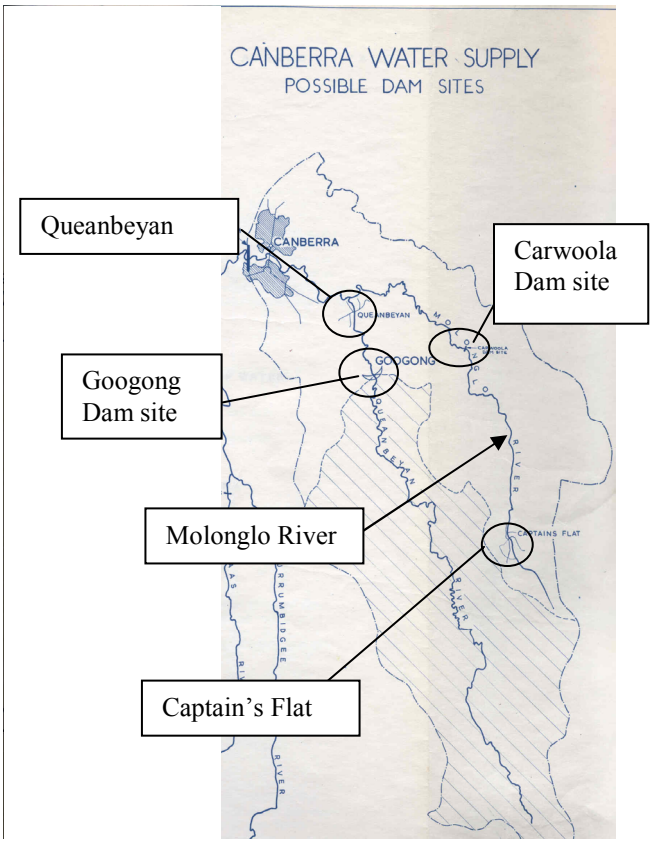
The proposal was unpopular with some groups and a strong coalition of farmers, fishermen, canoeists and conservationists formed the Coalition Against Welcome Reef Dam. The NSW Government has now permanently deferred plans for a dam at Welcome Reef on the Shoalhaven River with the creation of the Welcome 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 shortlisted.

Figure 18: Carwoola Dam site



Lower Cotter Dam

The existing lower Cotter Dam and Cotter pump station are part of Canberra's water supply. They have always been in reserve for emergency situations. The ability to use Cotter Dam water will be enhanced on completion of the new Stromlo Water Treatment Plant.

Therefore the existing lower Cotter supply is not considered a new supply, and hence is not included on the shortlist.

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 Stage 1 because there were better options to consider further.

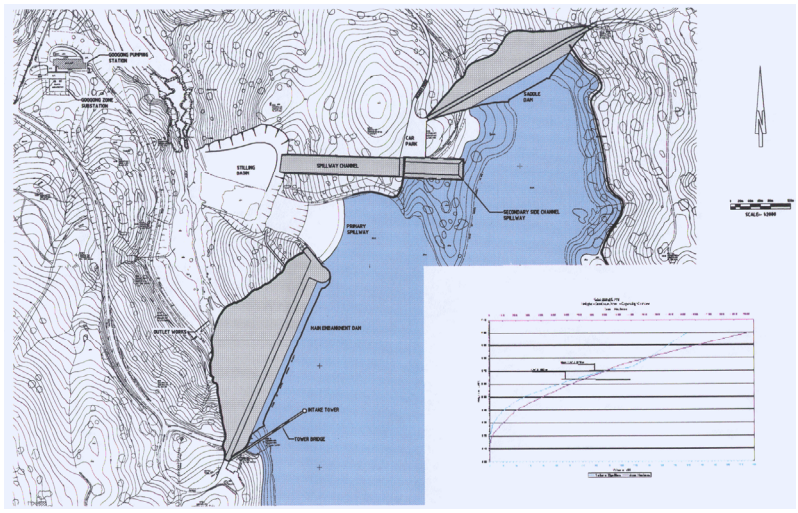
The cost of the "fuse plug" option (see below for more about "fuse plugs") would be around $4m. Although it could be done relatively quickly, it would not provide much additional storage, hence it has not been investigated further.

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 (ie. the dam's capacity to continue supply through a drought) would be much more modest, more like 25 per cent.

Figure 19: Enlarged Googong Dam



In the 1963[9] and 1968[10] 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 into Stage 2 and this option is not considered further.

Raising Googong spillway – "fuse plug"

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.

9[9]Department of Works, *Report on Proposed New Storage Canberra Water Supply*

10 Department of Works, *Report Canberra Water Supply Augmentation*

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 in this report. It does not produce enough extra yield to be considered as a "next source", but is more a refinement of an existing source.

ABBREVIATIONS

ACT	Australian Capital Territory
ACTEW	ACTEW Corporation Ltd
GL	Gigalitre
L	Litre
ML/d	Megalitre per day
NCP	National Capital Plan
NSW	New South Wales
WTP	Water Treatment Plant

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