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# AN INDEPENDENT REVIEW OF THE NEED FOR TILLEGRA DAM

ISF: RESEARCH

INSTITUTE FOR SUSTAINABLE FUTURES

THE WILDERNESS SOCIETY

Institute for Sustainable Futures

UNIVERSITY OF TECHNOLOGY SYDNEY

# AN INDEPENDENT REVIEW OF SUPPLY-DEMAND PLANNING IN THE LOWER HUNTER AND THE NEED FOR TILLEGRA DAM

August 2009

For The Wilderness Society Newcastle

Institute for Sustainable Futures, University of Technology Sydney

# Disclaimer



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## Abbreviations

| | |
|---|---|
| HWC | Hunter Water Corporation |
| ISF | Institute for Sustainable Futures |
| IPART | Independent Pricing and Regulatory Tribunal |
| IWRP | Integrated Water Resource Plan |
| NWC | National Water Commission |
| SCA | Sydney Catchment Authority |
| SKM | Sinclair Knight Merz (Consulting Engineers) |
| WSAA | Water Services Association Australia |

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# Executive summary

## *The Tillegra Dam: a huge cost for an unnecessary and wasteful level of supply*

In November 2006, the then New South Wales Premier Morris Iemma announced that a large dam would be built at Tillegra on the Williams River.

The premier's announcement circumvented established urban water planning processes which are designed to prevent Hunter Water Corporation (HWC) from imposing unjustifiable costs on its customers. The financial cost of the dam will now be recovered from Hunter Water's consumers despite the fact that they have not had any input into the decision.

The cost of the dam when announced was $300 million, however the cost was estimated at $477 million in the 2009 state budget with construction yet to start. As well as this significant financial cost to the region, in the Upper Williams River valley the dam would see the loss of a long-standing rural community, 21 square kilometres of well-watered fertile farmland, and an ecologically intact river.

The proposed dam would triple Hunter Water's surface water storage capacity and would be able to meet 74% of current water consumption in the Lower Hunter by itself. Such an extraordinary increase in capacity is unlikely to ever be required.

The scale of the oversupply can be seen in an analysis by Sinclair Knight Merz (SKM) which showed that once the Tillegra Dam is built there would be only a one in 1,250 years chance of entering Level One water restrictions[1] in the Lower Hunter. There would be very little likelihood of even these mildest of water restrictions being imposed in the Lower Hunter during the lifetime of the dam. This is despite the strong support for appropriate use of water restrictions being demonstrated by communities in surveys around the country.

## *The reasons given for the dam are unsound and unsupported*

The four reasons that have been given by the NSW Government and HWC for building the Tillegra Dam are that it is needed: to supply the Central Coast, to deal with climate change, to provide drought security and to meet future water demand in the Lower Hunter. These reasons are not supported by the available evidence.

### Supply for the Central Coast

In the year after the dam's announcement, the Gosford-Wyong joint water authority on the Central Coast was given an $80 million federal grant to augment their existing water supply system with a new pipeline from Mardi to Mangrove. This means that the region can satisfy its own water supply needs for the next 40 years.

### Climate change

Hunter Water has stated that long-term climate change is a key reason for building the dam. Without regional climate analysis, it has assumed there will be a 10% reduction in rainfall. Applied simplistically, this assumption translates to a reduction in run-off of approximately 25%.

[1] Level One water restrictions in the Lower Hunter consist of limits to the allowed outdoor watering times. Similar water using rules have been made permanent in other Australian cities including Sydney.

However, region-specific modelling, conducted by the NSW Government, predicts that in the Hunter region, climate change will see slight increases in both rainfall and run-off and that these factors are likely to more than offset an expected increase in evaporation. This prediction is confirmed in the most recent regional climate change modelling by the University of Newcastle which found no significant change in rainfall or runoff in the Hunter in their forecasts to 2080.

In its review of the Lower Hunter water supply, SKM concludes that it is not necessary to include potential changes to rainfall and run-off into supply estimates as future changes in climate are expected to have a neutral impact on water supply.

## Drought security in the Lower Hunter

The current water supply in the Lower Hunter has been shown to have high levels of drought security. Hunter Water estimates that there is only a one in a million chance of supplies falling to critical levels in any given year. This means that if the Tillegra Dam is being built for drought security, it is being built for an event that is predicted to occur only once in a million years. Analysis by SKM also shows that the existing system will retain high levels of drought security with increased levels of demand.

Since the early 1980s there have been no water restrictions imposed on consumers in the Lower Hunter and drought security is at a 30 year high due to decreased consumption and increased storage volumes.

## Long-term supply for the Lower Hunter

This review found that water consumption in the Lower Hunter in 2007/08 was the lowest recorded for 40 years, at 67 GL, and the five-year average was 70 GL per year, which is trending downwards from earlier decades.

The review also found that Hunter Water has unnecessarily reduced its estimate of available supply for the existing supply system from 90 GL to 67 GL per year. A more reasonable approach to estimating the available water supply would see the system yield remain at 90 GL per year. Water demand forecasts by HWC appear overestimated and more realistic projections show that with demand management, water consumption in the Lower Hunter could remain well below 90GL per year until 2050.

The Lower Hunter is far from an emergency situation with regard to either long-term water supply or drought security. In fact spare supply capacity and drought security have been increasing for several decades.

## *The alternative: a sustainable urban water strategy the public can support*

Because the region is in no immediate danger of water shortages, adequate time is available for a full, open and integrated sustainable urban water planning process which includes genuine community engagement.

The NSW Government directives to Hunter Water and IPART concerning the building of the Tillegra Dam should be revoked and a planning process based on current water industry practice should be initiated. Such a process would consider all the options. This would mean taking demand management, wastewater re-use, rainwater collection and stormwater harvesting seriously, properly assessing them and funding them appropriately.

This planning process would almost certainly include the most cost-effective water conservation measures such as ‘long-term water savings rules’ or ‘water wise rules’ and ‘mandatory water savings action plans’ for high consumers. Such measures are in place in other large Australian cities but are not yet implemented in the Lower Hunter.

It would also include a robust drought management plan for that ‘one in a million’ chance of reaching critical storage levels. This plan could be based on ‘readiness’ options for which all the planning, design and approvals have been conducted well before any extreme drought event. Potential ‘readiness’ options for the Lower Hunter include additional groundwater and desalination. The important point here is that unlike the dam, these options are designed so that there is a very low risk of actually needing to construct them.

Most importantly the planning process would involve the community in the key decisions about urban water in the Lower Hunter. This would lead to a sustainable urban water strategy with public support.

# 1 Introduction

This report was prepared by the Institute for Sustainable Futures (ISF) at the University of Technology, Sydney. It examines the rationale given for building the Tillegra Dam and assesses the water supply-demand planning situation in the Lower Hunter.

In preparing this report, ISF:

- reviews water supply planning documents for the Lower Hunter produced by Hunter Water Corporation before and after the plans for the dam were announced
- reviews Hunter Water's estimates of the available water supply in the Lower Hunter and Hunter Water's and SKM's analysis of the supply system's ability to cope with drought
- reviews Hunter Water's water demand forecasts.

Based on these reviews, ISF re-evaluates the water supply-demand situation in the Lower Hunter and puts forward the key elements of an alternative sustainable urban water strategy for the Lower Hunter.

The outline of this report is as follows.

Chapter 2 provides a background to the decision to build the Tillegra Dam and the current water supply-demand planning situation in the Lower Hunter.

Chapter 3 outlines the Tillegra Dam proposal and its implications.

Chapters 4 and 5 review Hunter Water's supply estimates and demand forecasts respectively. Key improvements are suggested.

Chapter 6 outlines ISF's re-evaluation of the water supply-demand situation in the Lower Hunter.

Chapter 7 outlines the key elements of an alternative sustainable urban water strategy for the Lower Hunter.

Chapter 8 presents ISF's conclusions and recommendations.

# 2 Background

In November 2006, the then New South Wales Premier Morris Iemma announced that the state-owned Hunter Water Corporation (HWC) would build the Tillegra Dam on the Williams River above Dungog. This chapter of the report shows that prior to Iemma's announcement, HWC itself rejected the need for the dam and that two of the three intended funding sources for the dam are no longer available.

The Premier's announcement circumvented established urban water planning processes which are designed to prevent HWC from imposing unjustifiable costs on its customers. It also set aside Hunter Water's established Integrated Water Resource Plan (2003) which had been reviewed only months before and which contained no plans for the dam.

Both the 2003 Integrated Water Resource Plan (IWRP) and its 2006 review focused on using water conservation and demand management measures as well as incremental increases in supply from existing sources to meet projected increases in demand (Hunter Water Corporation 2003, 2006).

The 2003 plan states that 'building a dam at Tillegra would be far less cost effective than many demand management and water conservation initiatives'. The Tillegra Dam was given the second-lowest rating of available supply augmentation options (Hunter Water Corporation 2003).

This lack of enthusiasm for the Tillegra Dam is consistent with comments from HWC officials reported in the *Newcastle Herald*. According to the Herald, in May 1998, then Managing Director David Evans said that:

> It's very difficult to imagine that we'd need it before the second half of next century … if we need it at all. The era of very large dams, I think, is just about gone (Ray 2009).

As recently as February 2006, the current Managing Director, Kevin Young, said that:

> Rather than build new dams we are making better use of our existing ones. Our long-term modelling tells us that we can be affected by extreme droughts and that the Hunter's population is expected to grow by 125,000 people over the next 25 years. A balanced plan is in place to meet these needs (Ray 2009).

HWC's review of its IWRP in October 2006 incorporated the final Lower Hunter Regional Strategy's population projection of 160,000 additional people by 2031 (Department of Planning 2006). Despite the population increase predicted in the Strategy, the IWRP review called for no change to HWC's plans – it merely stated that conservation measures and incremental increases in supply may have to be introduced sooner than originally anticipated. As a Hunter Water memo written in October 2006 and released from privilege in the NSW Legislative Council in July 2009 shows, there was no supply-demand planning to support the government's decision to build the Tillegra Dam and nor was there a robust costing of the proposal (Young 2006).

Nine months after the Premier's announcement, Hunter Water produced 'Why Tillegra Now?', a paper intended to justify the decision to build the Tillegra Dam (Hunter Water Corporation 2007c). In this document, HWC reduces its estimate of the water available to the Lower Hunter from 90GL per year to 67.5 GL per year. This is a level well below current and historic levels of water actually supplied.

As described in detail in Chapter 4 in this report, Hunter Water arrives at this lower figure by introducing into its modelling a new drought security criterion – a criterion that is unusually complex and which contains flawed and arbitrary assumptions. With more standard drought security criteria, no reduction occurs.

The ‘Why Tillegra Now?’ paper does not question the need to introduce a major new water source in the Lower Hunter. Rather, it compares the proposed dam to other very large supply options and concludes that it is the best of those options.

Since the ‘Why Tillegra Now?’ paper, Hunter Water has produced two more water supply-demand planning documents: the IWRP 2008 report to the Independent Pricing and Regulatory Tribunal (IPART) (Hunter Water Corporation 2008b) and the H250 Plan (Hunter Water Corporation 2008a). Neither document questions the government’s decision to build the Tillegra Dam.

Originally, the government planned to pay for the dam from three sources: increased customer water bills in the Lower Hunter, increased customer water bills on the Central Coast, and levies on developers. However, since then the state government has announced that development levies cannot be used as a funding source, and the NSW Minister for Water has ruled out Central Coast water prices having to rise to pay for the dam. As IPART’s 2009 pricing review makes clear, the dam will now be paid for solely through customer bills in the Lower Hunter (Independent Pricing and Regulatory Tribunal NSW 2009b).

IPART regulates the price of water and water services in Sydney, the Lower Hunter and the Central Coast and normal practice is for water agencies to be required to justify proposed capital expenditure. Usually, IPART decides whether proposed expenditures are warranted, and whether it will allow utilities to justify their price increases on the basis of such expenditures. However, a NSW Government directive (16A) to IPART prevented the tribunal from investigating or reporting on whether the Tillegra Dam is needed (Independent Pricing and Regulatory Tribunal NSW 2009b).

In its pricing submission to IPART in October 2008 (Hunter Water Corporation 2008c), Hunter Water identified the alternative drought security measures to the Tillegra as being additional bores in the sand beds at North Stockton and Tomago, and desalination. If adopted, these drought security measures would cost $155 million (Hunter Water Corporation 2008c). Because the NSW Government’s directive restricted IPART to considering only the ‘efficient costs’ of the Tillegra Dam, IPART was unable to examine whether the dam was the best option for the Lower Hunter and ask why Hunter Water customers should pay an addition $300 million for the dam over the identified alternative.

# 3 The Tillegra Dam proposal

If built, the Tillegra Dam will be on the upper Williams River above Dungog. The dam would be a concrete-faced rock-filled wall 800 metres long and 80 metres high. It would inundate 2100 hectares of the Upper Williams River valley and 21 kilometres of ecologically intact river. The dam would hold 450 GL of water which is roughly equivalent to the volume of Sydney Harbour. It would be the first large on-river dam built in NSW since the Copeton and Tallowa dams were completed in 1976.

## *3.1 Reasons given for building the dam*

In November 2008, the proposed Tillegra Dam was referred to the federal government for assessment under the *Environment Protection and Biodiversity Conservation Act 1999.* The referral put forward the following reasons for the dam:

- a need to improve drought security for existing customers in the Lower Hunter region
- threats to the region's water supply due to long-term climate change and the current drought being experienced across much of the country
- significant predicted population growth in the Lower Hunter region.

## *3.2 Not needed for supplying the Central Coast*

At the time of the election campaign in late 2006, Hunter Water was piping large amounts of water to neighbouring Central Coast councils where severe water restrictions were in force. Premier Iemma stressed the need for a new supply for the Central Coast when he announced the dam. An article in the *Daily Telegraph* when the dam was announced focused on this rationale, stating:

> A dam the size of Sydney Harbour will be built north of the capital to secure water supplies for Central Coast and Newcastle residents for the next 60 years.
>
> With the state government under attack over its response to the water crisis, Premier Morris will today announce plans to build the first dam in NSW for 30 years.
>
> He said the crisis facing Central Coast residents in the grip of drought should never be allowed to happen again….
>
> 'With the Central Coast's dams standing at only 15 per cent full and no long-term recovery in sight, now is the time for bold and far-sighted action,' Mr Iemma said. (Benson 2006)

However, since then the Gosford-Wyong joint water authority has decided to augment the Central Coast's existing supply system using an $80m grant from the federal government for the construction of the 'Mardi to Mangrove' pipeline. This means that the Tillegra Dam is not needed to provide water to the Central Coast (Gosford and Wyong Shire Councils 2007) and therefore customers on the Central Coast will not be expected to help fund its construction (Independent Pricing and Regulatory Tribunal NSW 2009a).

## 3.3 The environmental, social and financial costs

In November 2006 the estimated cost of the dam was $300 million. Since then, the estimate has risen to $477 million (as reported in the 2009 NSW state budget) and construction is yet to start. The full financial cost of the dam will be borne by Hunter Water's consumers, yet these consumers were not consulted about the decision to build the dam.

There will be local economic impacts if the dam is built. Not only will water rates increase, but the local council will forego the rates it currently receives from the land to be inundated.

As well as the financial cost, the scheme would have social and environmental impacts in the Upper Williams River valley. The dam would:

- destroy a long-standing rural community
- inundate 21 square kilometres of well-watered, irreplaceable agricultural land
- displace 90 farming families, many of whom have been in the region for generations
- inundate important historical sites including a number of graveyards.

The NSW Department of Water and Energy's Report Card for Williams River Water Source identified the Williams River as having a high rating for in-stream values. The area slated for inundation contains eight threatened amphibian species and six threatened bird species. A recent study identified at least 31 platypus and 26 platypus habitat pools which would also be submerged (Rubeli 2008). This is an area with high species diversity, high fish community integrity and high-quality wet flora. The ecological value of the river for invertebrates is also deemed to be high (NSW Department of Water and Energy 2008). The dam would also have downstream impacts, particularly on the Hunter estuary wetlands which are of international significance and are listed under the RAMSAR convention. The population of Australian Bass in the Williams River is considered the best wild population left on the NSW coast. The large impoundment and fish barrier caused by the proposed Tillegra Dam would destroy this population (NSW Department of Water and Energy 2008).

Methane and carbon dioxide emissions from the surface of the dam are likely to be significant. These gases are emitted when flooded organic material decomposes.

## 3.4 A massive oversupply for the Lower Hunter

It is obvious that the Tillegra Dam would provide an extraordinary and unwarranted level of drought security for the Lower Hunter. It would more than triple Hunter Water's surface water storage capacity. The dam would be able to meet 74% of all current water demand in the Lower Hunter by itself. Such an increase in supply is unlikely ever to be required.

Since the early 1980s there have been no water restrictions imposed on water consumers in the Lower Hunter and the scale of the oversupply can be seen in an analysis done by SKM for IPART which compares projected restriction frequencies with and without the dam (Sinclair Knight Merz 2008).

If water demand rose to 85 GL/yr, which is 21% above current levels, once the Tillegra Dam was built there would be a one in 1,250 years chance of entering Level

One water restrictions in the Lower Hunter. Across the Australian water industry it is common for water utilities to accept a one in 20 years frequency of water restrictions.

Even if at some point in the distant future, water demand in the Lower Hunter grew to 108 GL per year, 54% above its current level, the chance of entering Level One restrictions would be once in 170 years, with the dam in place (Sinclair Knight Merz 2008). If the Tillegra Dam is built, the children and grandchildren of current residents are highly unlikely to experience even Level One water restrictions during their lifetimes. In fact, there would be very little likelihood of even these mildest of water restrictions being imposed in the Lower Hunter during the lifetime of the dam.

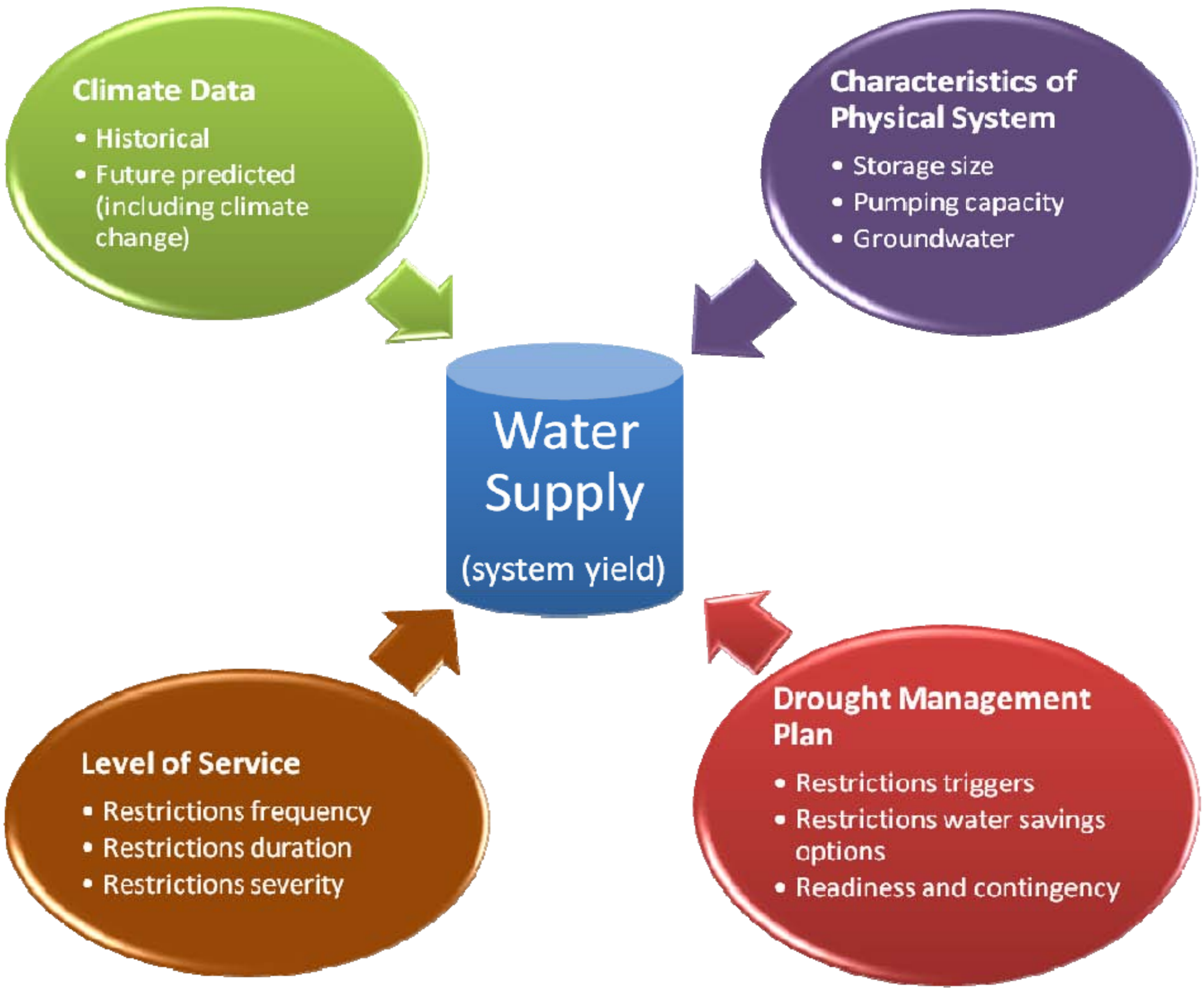
Given that similar water restrictions are now permanent 'water wise' rules in most other Australian cities and surveys around the country have shown that low-level water restrictions have very high levels of community support, such levels of supply are clearly unnecessary.

# 4 Review of water supply estimates

The estimation of available water supply for a town or city takes into account a range of factors. Naturally, water supply relies on climatic and hydrological factors such as rainfall, runoff, and evaporation as well as the physical characteristics of the water supply system such as storage sizes, pumping capacity and the amount of accessible groundwater.

Estimates of the annual available water supply, known as the 'system yield' or 'yield', also require assumptions to be made about what 'level of service' the community expects from the water supply and what the drought management plan for the water supply will entail. The 'level of service' is defined as 'the frequency, severity and duration of water restrictions that a community can expect' (Erlanger & Neal 2005).. The drought management plan takes into consideration key information about restrictions and drought contingency triggers as well as the water savings that can be expected at various levels of water restrictions. Figure 4.1 below illustrates the factors that impact on the available water supply or yield from a given supply system.

**Figure 4.1 Factors influencing the available water supply or yield**



## 4.1 Hunter Water's supply estimate

As Figure 4.1 illustrates, estimates of the available yield from a water supply system require assumptions about the acceptable 'level of service' that the community expects from that supply system.

Approximately nine months after the plan to build the Tillegra Dam was announced, Hunter Water changed the 'level of service' assumptions it uses to estimate the system yield. As a result, Hunter Water reduced its estimate of the Lower Hunter's supply from 90 GL per year to 67.5 GL per year (Hunter Water Corporation 2007c). The new yield estimate is well below current and historic levels of water consumption.

This reduction came about because Hunter Water included a new drought security criterion when defining its level of service. Prior to this, Hunter Water had only used reliability criteria to define its level of service.

The two reliability criteria used by Hunter Water to define level of service in their system yield estimate are that:

I. drought restrictions should not occur more frequently than once every 10 years

II. restrictions should not be applied more frequently than 5% of months over the long term (Hunter Water Corporation 2007c)

These criteria are not unusual when compared to those of other cities around Australia. However, the new drought security criterion introduced by Hunter Water in August 2007 is unique:

III. [the supply system should] provide storage to meet four years' supply below the drought trigger and enough storage above the drought trigger to satisfy demand during a 1 in 100 year drought. (Hunter Water Corporation 2007c)

The drought security criterion Hunter Water chose is complex and did not take a form used by other water utilities. As other authors have noted, Hunter Water's approach to developing a drought security criterion has not been used elsewhere in Australia. SKM's review of the yield assessment describes the criteria used by Hunter Water as 'unique and possibly very conservative' (Sinclair Knight Merz 2008).

Critically, Hunter Water also introduced a series of flawed and arbitrary assumptions into this drought security criterion and these assumptions resulted in the reduced yield estimate of 67.5 GL per year.

## 4.2 Issues identified with current supply estimate for the Lower Hunter

In reviewing Hunter Water's supply estimates a number of specific issues arise:

1. The incorporation of climate change into supply planning appears simplistic as it applies a 10% reduction in rainfall for every day and has not addressed a range of climate change scenarios.

2. The use of contingency or 'readiness' options are now considered good practice in the water industry. This involves preparing to build a desalination plant. In HWC's assessment, a 48 month lead time to build a plant has been assumed. This is highly conservative assumption, as in the Sydney

metropolitan water plan, a 26 month construction time was expected and this was for a larger, more complex plant.

3. The use of a parameter within the new drought criterion stating that 'the planning process for construction of a desalination plant should be triggered only once in one hundred years'. This chosen parameter is arbitrary and has not been sensitivity tested. If the frequency were increased, a significant increase in yield is likely to be available at a small risk weighted cost.
4. The assumption of a 'minimum supply' requirement within the new drought criterion is assumed to be 70% of unrestricted water demand. This is unlikely to represent a true minimum water supply that the community would accept in the extremely rare event of an emergency drought situation. This assumed 'minimum supply' level is a critical input to Hunter Water's drought security criterion.
5. The use of a repeated drought sequence without historical precedent as part of the estimation of yield.
6. The lack of sensitivity testing of key parameters within the new drought criterion.
7. The failure to survey the community in the Lower Hunter on its willingness to pay to avoid drought measures. This is an issue because community input is key to defining 'level of service' criteria.
8. Hunter Water's system yield estimate of 67.5 GL per year is below current and historic levels of water consumption and does not appear to reflect the actual performance of the water supply system.

## *4.3 The incorporation of climate change*

The argument that climate change is a key driver for the Tillegra Dam has been used by Hunter Water and the NSW Government without the support of convincing data. No comprehensive analysis of climate change scenarios is evident in documentation relating to the dam. Furthermore, the most recent climate change projections suggest a neutral climate impact on the Lower Hunter area.

Hunter Water discusses a single climate change scenario in 'Why Tillegra Now?' and its $H_2$50 plan. This scenario is based on a simplistic analysis which assumes a 10% drop in rainfall for every day of the year. The 10% rainfall assumption translates into a 25% reduction in run-off once incorporated into yield modelling (Hunter Water Corporation 2008a).

Applying a simple proportion such as 0.9 across all rain events in the historical record does not allow for temporal and spatial variability. It is not a realistic climate change scenario and would not be accepted as good practice by water industry peers.

Despite its unorthodox and simplistic modelling of climate change impacts, Hunter Water states in its 'Why Tillegra Now?' paper that:

> the vulnerability of the lower Hunter water storages to drought, and the potential impact of climate change are the two dominant factors to be considered in water resource planning for the region. Clearly something must be done to avert a bleak future of increasing the frequency and duration of

water restrictions and higher risk of running out of water (Hunter Water Corporation 2007c).

In SKM's review of Hunter Water's yield calculations, the likelihood of different climate change scenarios has been evaluated. SKM highlights the fact that the CSIRO's 2007 projections for climate change predict a 2% decrease in rainfall by 2030 and a 5% decrease by 2070 and that this decline is only for winter, spring and autumn. In summer a 2% *increase* is predicted. In contrast, the NSW Department of Environment and Climate Change predicts an *increase* in rainfall across all seasons except winter in their climate models for the Hunter region.

These predictions are further supported by a recent University of Newcastle / local government study into climate change impacts in the Hunter which found that 'No statistically significant change in overall average annual rainfall patterns are projected to occur. Overall rainfall extremes are also projected to stay within the limits of known natural variability' and that 'seasonal shifts in the Coastal and Central Zones balance out to produce no projected change on an annual basis' (Goodwin & Blackmore 2009).

Water utilities in Australia that are comparable to Hunter Water have developed climate change scenarios for use in urban water planning based on detailed regional climate modelling. As other reviewers have pointed out, it is standard practice to consider a range of climate change scenarios and base discussions around these (Rhodes & Yurisich 2008).

SKM concludes that on balance, the projections suggest that by 2050, rainfall in the Lower Hunter will increase and that this increase is likely to be offset by increased evapotranspiration. Consequently, SKM does not consider it necessary for HWC to include any changes to rainfall and stream flow in its water supply models for the next few decades (Sinclair Knight Merz 2008).

ISF agrees with SKM on both of these conclusions. However over time Hunter Water should also look to develop a range of climate change scenarios based on the latest climate projections for the Hunter region.

## *4.4 Hunter Water's drought security criterion*

HWC's third and most recent level of service criterion, the drought security criterion, introduces both flawed and arbitrary assumptions into the yield calculation that have not been sensitivity tested. These include: the assumption that the desalination plant would take four years to build, the assumption that starting to plan for a desalination plant should only happen once in 100 years, the assumption that there is an absolute minimum supply requirement that can be quantified, and the assumption that a repeated drought sequence with no historical precedent is suitable for use in yield calculations.

Hunter Water's justification for introducing this new drought security criterion relies heavily on a quote from Water Services Association Australia (WSAA) Occasional Paper 14, which states that 'it is expected and understood that water utilities manage their water resources so that communities never run out of water' (Erlanger & Neal 2005). This statement is interpreted in HWC's document 'Why Tillegra Now?' as a direction to develop a 'zero risk' drought security criterion for their water supply system (Hunter Water Corporation 2007c). However, Erlanger and Neal note in the very next paragraph of their WSAA report that:

> restrictions will be required … unless water supply systems are 'gold plated' through the construction of generous buffer supplies. Such buffers come at a high economic and environmental cost and are hard to justify when they may only be required once every 20 years (Erlanger & Neal 2005).

The Tillegra Dam proposal represents exactly this – a generous buffer supply, which comes at a high economic and environmental cost. The Lower Hunter community needs to be consulted if they are to pay for such a 'gold plated' water supply system.

Erlanger and Neal go on to elaborate on the objectives of a water utility and how it should meet them, stating:

> Water utilities have a responsibility to supply water to the community, but at the same time they are running a business that must balance increasing demands for water due to population growth with the cost of supply and the willingness of the community to pay for that water. Costs include the financial, social and environmental cost of supply.
>
> The primary objective of a water utility is to ensure that the community has a safe and reliable water supply system and to communicate this to consumers. This does not mean that there will never be restrictions, but it does mean that a community can expect to never run out of water. This primary objective consists of three main components, namely that:
>
> i. the supply system has the capacity to maintain an adequate level of supply over most periods in the long term,
> ii. when drought periods occur, a drought response plan provides short-term protection against running out of water through the implementation of water restrictions…., and
> iii. in cases of extreme drought, a contingency or emergency plan exists that ensures that basic water needs for a community can be met for the duration of the emergency (Erlanger & Neal 2005).

This quote highlights two further key points missed by Hunter Water when introducing their new supply system drought criterion: firstly that it is important to survey the community's willingness to pay for the level of service, and secondly that the community's expectation of never running out of water is not to be met solely by 'supply system capacity' but by having a 'drought response plan' and a 'contingency or emergency plan'. These issues are simply compounded by the problematic assumptions outlined below.

## Four years of storage below the drought management plan trigger

The 'four years of water supply in storage' parameter (that there should always be enough water in storage to supply consumers with water for four years) within Hunter Water's new drought security criterion is based on assumptions about how long it would take to plan and construct a desalination plant.

Hunter Water has adopted four years as the required lead time in their yield analysis, which appears lengthy considering the construction times for much larger plants, such as the Sydney Metropolitan Water plan (26 months) and the second desalination plant in Perth, where construction is set to commence in 2009 and finish in 2011.

Part of the reason that this lead time is so long is that HWC has included the planning and approvals stage within this period. If this stage were undertaken well ahead of time, then the lead time for building the desalination plant could be reduced and yield would be increased.

As was noted in the 'Review of the Metropolitan Water Plan' in relation to desalination plant construction in Sydney for the NSW Government cabinet office:

> The ability to construct desalination capacity in a short time (26 months) is the result of the planning, approval and testing processes that are almost completed, and which collectively have reduced the lead-time to construct by at least 12 months — to about 26 months. This readiness greatly increases supply security by allowing a plant to be committed, constructed and started late in a severe drought in sufficient time to avoid breaching security requirements. This in turn limits the risks of committing to a high cost construction project, only to have the drought break, with adequate supplies still in storage — effectively resulting in a wasted investment (White et al. 2006).

Interestingly, after the Tillegra Dam was announced, the assumed lead times for desalination construction in HWC's drought contingency or emergency plan were significantly increased. The drought planning parameters adopted by HWC in their 2006 Drought Management Plan (DMP) have been compared with the revised versions from the 2007 closed board minutes in the Table 4-1 below.

**Table 4-1 Drought planning parameters from the HWC's 2006 Drought Management Plan and revisions made in 2007 (Hunter Water Corporation 2007a)**

| | *2006 DMP* | *Revised 2007* |
|---|---|---|
| **Lead time – planning and construction** | 36 months | 48 months |
| **Lead time – Construction** | 18 months | 36 months |
| **Trigger for desalination construction (assuming planning has occurred)** | 19% of storage, which HWC predicted to occur once in 20,000 years | 46% of storage which HWC predicted to occur once in 130 years |

The issue of lead times is critical to the yield estimate, because as SKM notes, 'the yield is sensitive to the time required to construct a desalination plant … [which] provides an opportunity to optimise yield if the construction period can be reduced' (Sinclair Knight Merz 2008).

## Assumed maximum one in one hundred year drought management plan trigger

A critical assumption in the new drought security criterion, and therefore the yield calculation, is that the drought management plan should only be triggered once in every 100 years. This figure appears to have been simply assumed and not sensitivity tested in material sighted by ISF (Hunter Water Corporation 2007a, 2007b).

As there is no basis for this assumption, this parameter needs to be sensitivity tested. If Hunter Water chooses to retain its new drought security criterion it should conduct a cost-risk analysis of an increase in the probability of triggering the drought plan. For example it should investigate the implications of triggering the drought plan once in every 50 years as an alternative.

Doubling the allowable probability for triggering the drought plan would have a dramatic impact on the resulting yield estimate.

## Minimum supply requirement

Hunter Water defines the minimum supply requirement – the minimum amount of water the community could survive on in an emergency situation (survival mode), as 40% lower than normal consumption for the residential sector and 20% lower for the non-residential sector, which is assumed to result in an overall reduction in consumption of 30% across both sectors (Hunter Water Corporation 2007c).

The use within Hunter Water's drought criteria of these estimates of the absolute minimum water required in a survival situation were critiqued by George Kuczera in his review of HWC's calculations. Kuczera notes that 'the concept of a minimum sustainable demand is convenient but probably not realistic' and that 'there probably isn't a threshold below which widespread economic and social collapse suddenly occurs' (Kuczera 2008). Indeed, assuming the existence of this threshold 'oversimplifies the situation' (Kuczera 2008).

A 40% reduction in residential water use in the Lower Hunter would result in a daily per capita water consumption of 125 L/person/day, which was similar to Brisbane's per capita water use target during the last drought (Kuczera 2008) but is higher than Brisbane's actual water consumption per capita later in the last drought which got down to 112 L/person/day (Queensland Water Commission 2008). This indicates that this assumption is probably high and not truly reflective of an emergency drought supply level. Clearly, water conservation does not reach a limit and is elastic, depending on the situation.

Importantly, Kuczera notes that 'the yield is likely to be sensitive to the minimum sustainable demand which is unlikely to be the sharp threshold assumed in the 48 month drought management plan'. He also suggests that it is worthwhile for 'Hunter Water to develop policies and strategies which lower the minimum sustainable demand ahead of a future severe drought' (Kuczera 2008). This highlights the fact that further adjustments to the drought management criteria are required to ensure that they are realistic and relevant – and do not unnecessarily understate the yield of the existing water supply in the Lower Hunter.

In Hunter Water's complex drought security criterion, the 'minimum supply requirement' assumption is important because it underpins the calculation of 'four years of storage' before reaching critical supply levels.

### Repeated drought sequence

Hunter Water's drought security criterion incorporates a repeated 'worst drought' sequence. This is done by taking the worst 12 months of drought on record for the Lower Hunter system and repeating it for four years in a row. The result is a highly protracted drought scenario with no precedent in the historical record.

The inclusion of this assumption in the drought security criterion means that Hunter Water's yield calculations are dependent on this artificial drought sequence.

It is also worth noting that the graph presented in the 'Why Tillegra Now?' paper (Figure 16) that illustrates a rapid depletion in Lower Hunter storages is based on this artificial drought sequence together with the minimum supply requirement assumption.

### The apparent lack of sensitivity testing

Hunter Water's new drought security criterion incorporates a number of assumptions and parameters which would appear to have a little basis and it is therefore important that they are sensitivity tested to examine what would happen if they are varied. This is critical, considering that HWC's assumptions and parameters have resulted in a significant down-rating of the existing supply system. The new parameters need to be sensitivity tested to verify their validity in yield estimates.

From the material available to ISF, including closed board reports, Hunter Water does not appear to have sensitivity tested significant parameters, in particular the 'one in 100 year' maximum allowable trigger for the drought plan, the 'minimum supply requirement' assumption and the desalination construction lead time of less than three years (Hunter Water Corporation 2007a, 2007b).

The problems with Hunter Water's lack of sensitivity testing are highlighted by the difference in yield estimates that results when more standard drought security criteria are applied to the Lower Hunter system.

As part of their review for IPART in 2008, SKM undertook a sensitivity analysis of HWC's criterion by using HWC's model to test the drought security criterion used by Sydney Catchment Authority (SCA). SCA's drought criterion states that 'the chance of reaching critical storage should be less than once in 100,000 months (8,333 years)'. SKM's analysis showed that under SCA's drought criterion, the Lower Hunter system would have a yield of 107 GL/yr if the figure was not limited to 90 GL by the restriction frequency criteria (Sinclair Knight Merz 2008). This highlights the conservative nature of the HWC criterion which results in a yield of 67.5 GL per year.

## *4.5 Community input to decide on the 'level of service'*

The level of service criteria for any water supply system are based on what the community is willing to accept in relation to drought response and what they are willing to pay for.

All communities could have water supplies without any risk of restriction if they were willing to pay for them. The community in the Lower Hunter has not been surveyed on its willingness to pay to avoid drought measures. However, as Table 4-2 below illustrates, the addition of the Tillegra Dam will reduce the likelihood of entering water restrictions to close to zero in any given year.

**Table 4-2 Probabilities for entering each stage of water restrictions, both with and without Tillegra Dam (Sinclair Knight Merz 2008)**

| Level of water restriction / supply type / year | Without a new supply | | With Tillegra Dam | |
|---|---|---|---|---|
| | **Demand at 85GL/yr** | **Demand at 108GL/yr** | **Demand at 85GL/yr** | **Demand at 108GL/yr** |
| **Level 1** | Once in 21 years | Once in 8 years | Once in 1250 years | Once in 170 years |
| **Level 2** | Once in 63 years | Once in 15 years | Once in 10,000 years | Once in 1000 years |
| **Level 3** | Once in 250 years | Once in 36 years | Less than once in 10000 | Once in 7140 years |

Analysis by SKM shows that even if demand were to rise to 85 GL per year (well above the current average of approximately 70GL) the Lower Hunter would enter Level One water restrictions only once in every 21 years without Tillegra Dam. This is a level considered acceptable by most utilities across Australia. However, if Tillegra Dam is constructed, the chance of entering Level One restrictions is reduced to once in 1250 years (Sinclair Knight Merz 2008).

As Erlanger and Neal (2005) point out in their report, ‘restrictions will be required from time to time in Australia because of the variability of rainfall, unless water supply systems are “gold plated”’. The community in the Lower Hunter needs to be consulted if they are to pay for the ‘gold plating’ of their water supply system.

Even IPART noted this extraordinary level of drought security in its draft price determination but could do nothing to question the decision to build the dam:

> After taking account of the impacts of predicted population growth, the construction of the dam will reduce the probability that drought restrictions are imposed in the Hunter region from 1 in 21 years to 1 in 1,250 years. This is a very high level of drought security and, to date, IPART has not been provided with evidence regarding the value of customers’ willingness to pay for this increased level of security (Independent Pricing and Regulatory Tribunal NSW 2009c).

‘Level of service’ criteria impact on the estimated water system yield and involve a choice for the community. Before setting these criteria, it is therefore imperative that water utilities seek community input into ‘willingness to accept’ drought measures and willingness to pay for increased drought security. Erlanger and Neal (2005) also note that ‘it is important that the urban water industry engages customers and stakeholders about how water supply systems work and the reliability of supply they can expect’ (Erlanger & Neal 2005).

## *4.6 Actual supply system performance in the Lower Hunter*

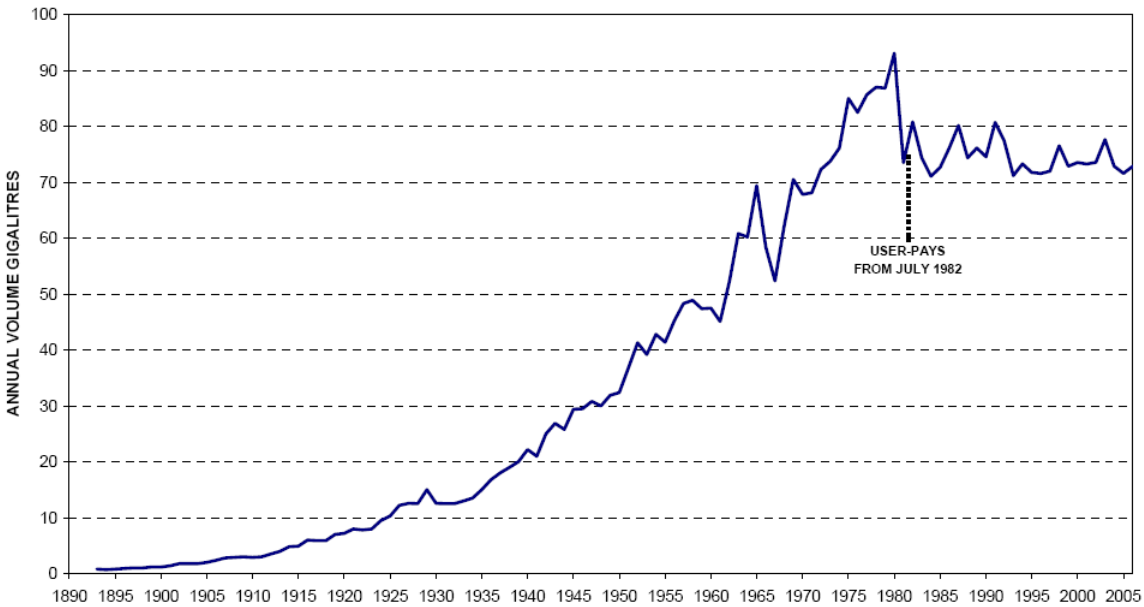
Significant questions need to be asked about Hunter Water supply estimates. The underlying assumptions Hunter Water is using are arbitrary and flawed and the estimates do not reflect the volumes of water that have been supplied historically.

Prior to 2007 it was accepted that the yield from the water supply system in the Lower Hunter could be estimated at 90 GL per year based on system reliability criteria. In 2007, using its new drought security criterion in the 'Why Tillegra Now?' paper, Hunter Water down-rated the system yield to 67.5 GL per year, a figure well below current and historical levels of water consumption.

This low system yield is not reflected in the historical or projected performance of the water supply system in the Lower Hunter with the supply system continuing to show both a low frequency of water restrictions and a high level of drought security.

The volume of water sourced from the Lower Hunter water supply system has been between about 70GL and 80 GL since 1982 with higher volumes sourced in the preceding decade (see Figure 4.2 taken from HWC's 2008 IWRP). Since 1970 the volumes supplied have been between 70 and 90 GL per year.

**Figure 4.2 Total supply from all sources for Lower Hunter water supply system (Hunter Water Corporation 2008b)**




The current supply system in the Lower Hunter has a high level of drought security. Modelling by Hunter Water estimates that there is only a one in a million year chance of reaching critical supply levels which are defined as 10% of total storage capacity (Hunter Water Corporation 2007a).

Analysis by SKM (2009b) also shows that the existing system will maintain high levels of drought security even if water demand increases. If demand rose to 85 GL per year there would be a one in 10,000 year chance of supplies falling to 20% of storages. This is a level above that defined by Hunter Water as critical.

In fact, as Hunter Water notes in a closed board minute (2007a), drought security in the Lower Hunter is at a 30-year high due to decreases in water demand and increased storage volumes over that period.

## 4.7 Improving supply estimates for the Lower Hunter

Suggestions for improving the available supply estimates in the Lower Hunter are included in Table 4-3 below.

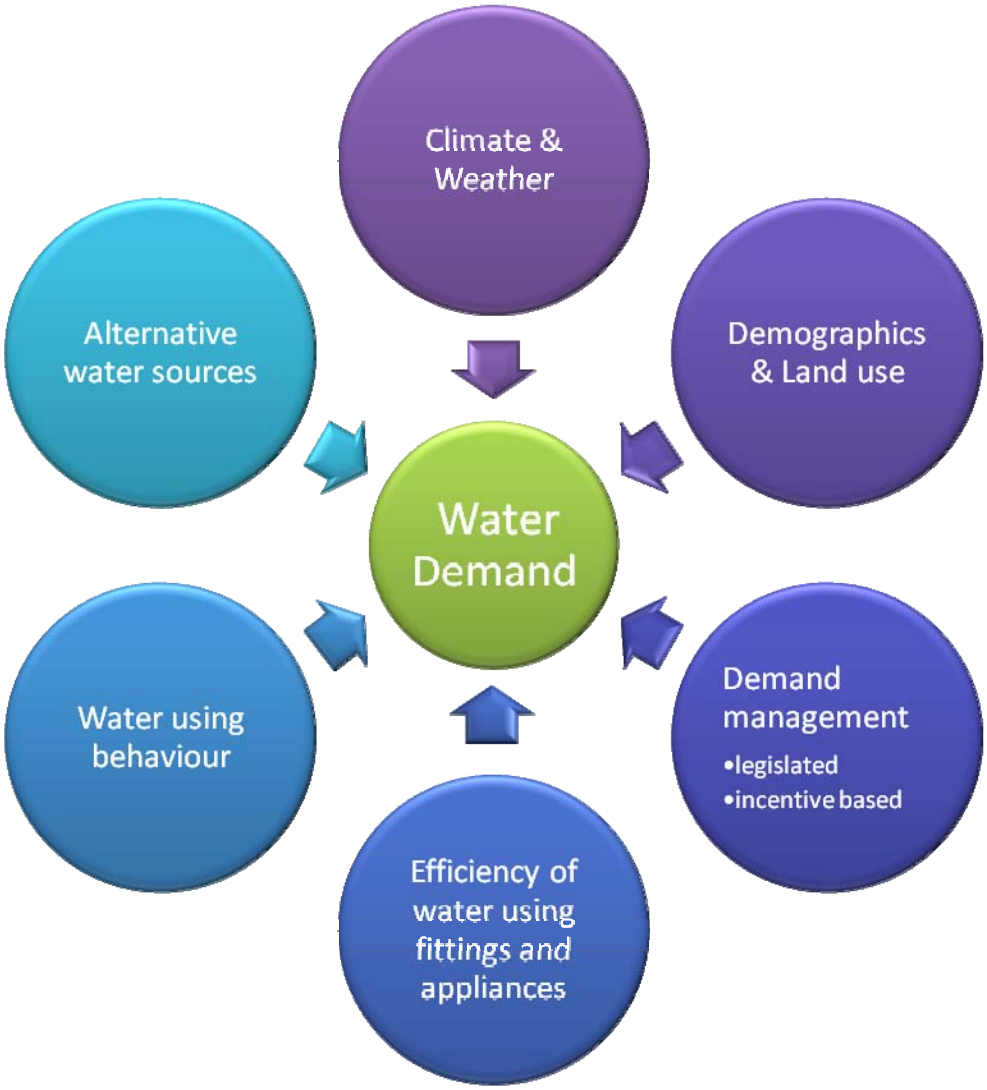
**Table 4-3 Suggested changes to the calculation of supply estimates**

| Issue identified | Suggested change |
|---|---|
| Incorporation of climate change | Based on available modelling, climate change impacts appear neutral for water supply in the Lower Hunter. Therefore no change to yield modelling is likely to be required. However, Hunter Water should develop a range of scenarios and should base its climate change scenario analysis on the latest climate projections for the Hunter region. |
| Drought security criteria | A standard drought criterion which reflects normal industry practice should be used in the yield estimate. It should reflect a very low probability of reaching critical storage levels. |
| Sensitivity analysis of key parameters in yield estimate | Hunter Water should conduct sensitivity analysis of critical parameters and optimise the yield of the existing system. |
| Setting ‘levels of service’ criteria | Hunter Water should seek community input on ‘willingness to accept’ drought measures and willingness to pay for increased drought security |

# 5 Demand forecasts

A city's demand for water is affected by a number of factors. These include the climate and daily weather; demographics such as population, type of dwellings and the land use; and the industries present. Demand is also affected by the range of demand management techniques applied by governments and water utilities. These include legislated demand reduction strategies such as BASIX, incentive-based demand management programs, rebates for efficient appliances, large-scale retrofits and community awareness programs. Such programs encourage the uptake of water-efficient fixtures and appliances and increase community awareness, leading to changed water using behaviour. Demands on the main supply system are also reduced by the introduction of alternative water sources such as rainwater tanks and by the introduction of water recycling schemes. The sum of these factors needs to be considered when forecasting future water demand.

**Figure 5.1 Factors influencing demand**



## 5.1 Hunter Water's demand forecast

Water consumption in the Lower Hunter has averaged 70 GL per year over the past five years. This reflects a downward trend in total water consumption over the last 25 years. The water consumption in 2007/08 was 67 GL, the lowest for 40 years (HWC 2008). Part of this reduction in demand over time is due to the closure of several high water-using industrial sites and the declining proportion of unmetered water consumption (Hunter Water Corporation 2007c).

Water restrictions played no part in reducing consumption during this period, as unlike other large urban regions in southern and eastern Australia, the Lower Hunter has not needed water restrictions since the early 1980s.

Hunter Water has predicted a sharp increase in water demand despite downward trends in water usage for the last 20 years.

In planning documents developed since the Tillegra Dam was announced, Hunter Water predicts that water consumption will rise to 90 GL by 2031 and 110 GL by 2051. Due to a number of issues with Hunter Water's assumptions and its demand forecasting technique, this is likely to represent a large overestimation.

## 5.2 Issues identified with current demand forecasts for the Lower Hunter

The demand forecasting calculations set out in 'Why Tillegra Now?' and subsequent planning documents do not appear to be sound due to the following issues:

1. The demand forecasting takes a broad brush approach rather than using detailed end-use modelling or statistical analysis
2. The historical demand data has not been corrected for climate using accepted methods i.e. multiple regression
3. The forecasting appears to underestimate the impact of the NSW Government's planning policy (BASIX) to reduce water use in new residential development
4. Water savings due to future demand management programs and water recycling initiatives have not been fully incorporated
5. Water savings due to future price increases appear to be underestimated
6. Unaccounted for water (UFW) and unmetered consumption are probably overestimated
7. The future residential and non-residential water use split is based on historical proportions despite the changing economic structure of region
8. The augmentation of the Central Coast's water supply system means that it is less likely to need water transfers. This change has not been incorporated into demand forecasts
9. High population growth rates are assumed and have not been sensitivity tested

All of these issues contribute to an overestimate of demand. Each issue is explained in further detail in this chapter.

## 5.3 Broad brush vs. end-use modelling

HWC's demand forecasting approach is more simplistic or 'broad brush' than approaches used by other similarly sized water utilities in Australia and is lacking in several areas. HWC's method is quantitative and uses estimates of population and dwelling growth rates to project demand based on a short historical consumption record (since 1993). This consumption data has not been adequately corrected for climatic variation (Sinclair Knight Merz 2009).

Broadly, the two methods most commonly used by water utilities for demand forecasting are:

1) Statistical analysis – This method uses multiple regression analysis of climatic factors such as evaporation, rainfall and temperature to determine the relationship between these factors and water demand. From this analysis, average water demand is estimated for future climate and population scenarios.

2) Detailed end-use modelling – This method is often referred to as a 'bottom up' approach. Detailed information on household water use, such as average shower durations, shower flow rates, number of toilet flushes and average flush volumes are used to build a picture of water demand. From this analysis, end-use parameters are altered to determine a range of scenarios for projected water demand.

In reviewing HWC's demand forecasts for IPART in late 2008, SKM states that two weaknesses of HWC's spreadsheet model are its 'heavy reliance upon quantitative estimates of future customer behaviour' and the fact that the model is not based on statistical analysis. SKM also notes that HWC's methodology is 'not supported by reporting on model development, model calibration or assumptions made in consumption forecasting' and that there was also no reporting on the analysis of historical consumption data (Sinclair Knight Merz 2009).

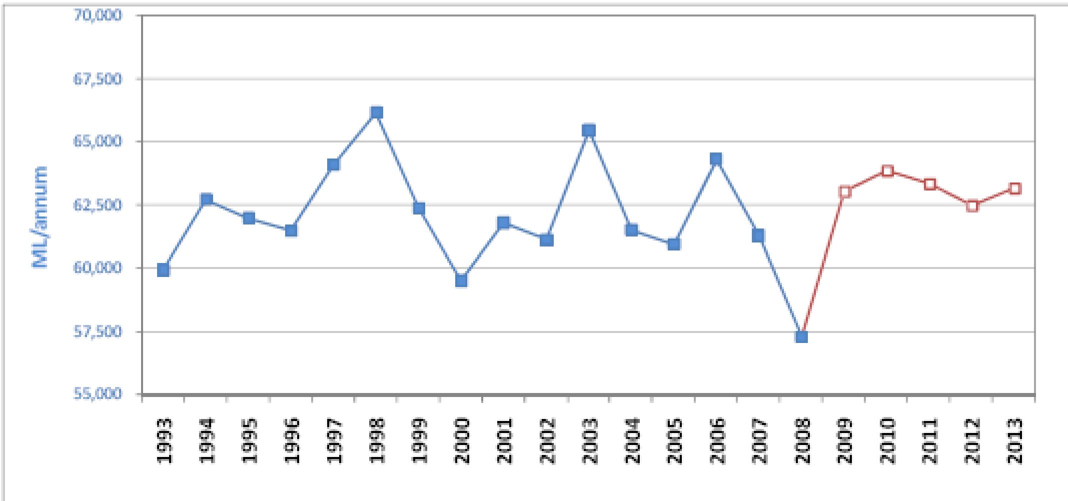
ISF and most major water utilities in Australia prefer to use end-use analysis and end-use modes to forecast demand. However, either of the two approaches identified would provide a more detailed and accurate prediction of future demand.

## 5.4 Climate correction

Climate correction is often an important component of demand forecasting as it aims to determine the relationship between climatic factors such as rainfall, temperature and evaporation, and water demand. This enables a more accurate prediction of future water demand.

HWC has used a highly simplified approach to climate correction which involves extrapolating from the last 15 years of water consumption data. This method cannot be considered an adequate climate correction, as it does not correlate the changes in consumption with climatic factors. It is merely a trendline or moving average that uses consumption data only. The aim of climate correction is to establish an average annual water demand that is not affected by extremes in weather conditions. This average should be determined by undertaking statistical analysis of consumption in relation to climatic factors. The corrected average water demand can then be used as a basis for forecasting future demand. HWC's method of climate correction results in a sharp increase in demand in 2009, which is said to be based on the assumption of returning to an 'average' climate. This sharp increase can be seen in Figure 5.2, which shows that the demand forecast by Hunter Water includes a sudden increase in consumption in 2009 and that projected demand is well above the average for the past 15 years.

**Figure 5.2 Historic and forecast demand for the Lower Hunter (Sinclair Knight Merz 2009)**




SKM and ISF recommend that HWC use a statistically based climate correction method for their historical consumption analysis.

## *5.5 Factors acting to reduce demand*

Aside from the issues associated with the demand forecasting method, there are a number of factors which will impact on demand that have not been adequately accounted for in HWC's analysis. These include legislated demand management such as BASIX, HWC's own demand management programs and price increases. All of these will act to reduce demand.

### BASIX

NSW BASIX legislation requires that all new households in Sydney, Newcastle and other areas reduce their water consumption by 40% from a baseline figure. HWC has made some broad assumptions regarding the base consumption of new detached dwellings (265 kL/a) and new multi-residential units (130 kL/a) but has not documented the origin of these figures. HWC has then applied a 26% reduction in water use for those new houses that have rainwater tanks and a 38% reduction for houses using dual reticulation (Hunter Water Corporation 2007c). However, neither of these assumed reductions is sufficient to meet the BASIX legislation requirement of a 40% reduction in water use.

Consequently, the demand forecast needs to be adjusted to match BASIX legislation requirements and in addition, end-use analysis is recommended in order to more accurately predict the baseline for water use and identify where savings can be made.

### Unaccounted for savings due to future demand management programs

SKM's review of HWC's demand forecast highlights the fact that HWC's future demand management programs have not been factored into their demand forecast.

These programs are expected to save 1.4 GL per year (Hunter Water Corporation 2007c)

In HWC's report, 'Why Tillegra Now?', the potential for rainwater tanks and recycling schemes is discussed, but does not appear to have been included in HWC's planning or its demand forecast.

HWC's $H_2$50 report states that, 'collectively the current and past programs have already saved an estimated 3,800 megalitres per year and are forecast to save in excess of 7,000 megalitres per year by 2020' (Hunter Water Corporation 2008a). HWC's projected expenditure on demand management, documented within the $H_2$50 report, remains at $5.3 million per year over the next five years with expected water savings more than doubling from 4.5 GL/year to 10.2 GL/year in 2013/2014 (Hunter Water Corporation 2008a). The investment of $5.3 million each year with no increase over time appears very small, especially considering that Sydney Water spent $129 million on demand management programs in 2007/08 and saved 76 GL (Sydney Water 2008). This suggests that even greater savings could be made through demand management.

## Underestimation of water savings due to price increase

Hunter Water has underestimated the influence of its proposed price increase on water demand. As SKM points out in its review, HWC's projections do not include any decrease in indoor residential or non-residential consumption (Sinclair Knight Merz 2009).

The current proposal is for a 31% price rise which would increase the cost of a kilolitre from $1.27 to $1.86 in 2012/13 (Independent Pricing and Regulatory Tribunal NSW 2009b). The estimated demand response needs to be applied across all sectors including indoor residential and non-residential. In addition, the demand reduction should be slightly increased to reflect the size of the price increase.

## Non-residential water use projection

A relatively high proportion (44%) of the current water consumption in the Lower Hunter is non-residential. This reflects the heavy industrial base that has been prevalent in parts of the region and it involves a small number of large users. This means that if more industrial users close down, then total demand could drop further. This uncertainty with regards to future demand from non-residential users has not been reflected in Hunter Water's demand forecasts.

In recent years non-residential water use has declined as a proportion of total consumption compared to residential use and is likely to decline further. This changing nature of non-residential water use needs to be accounted for in the demand forecast.

## Transfers to the Central Coast

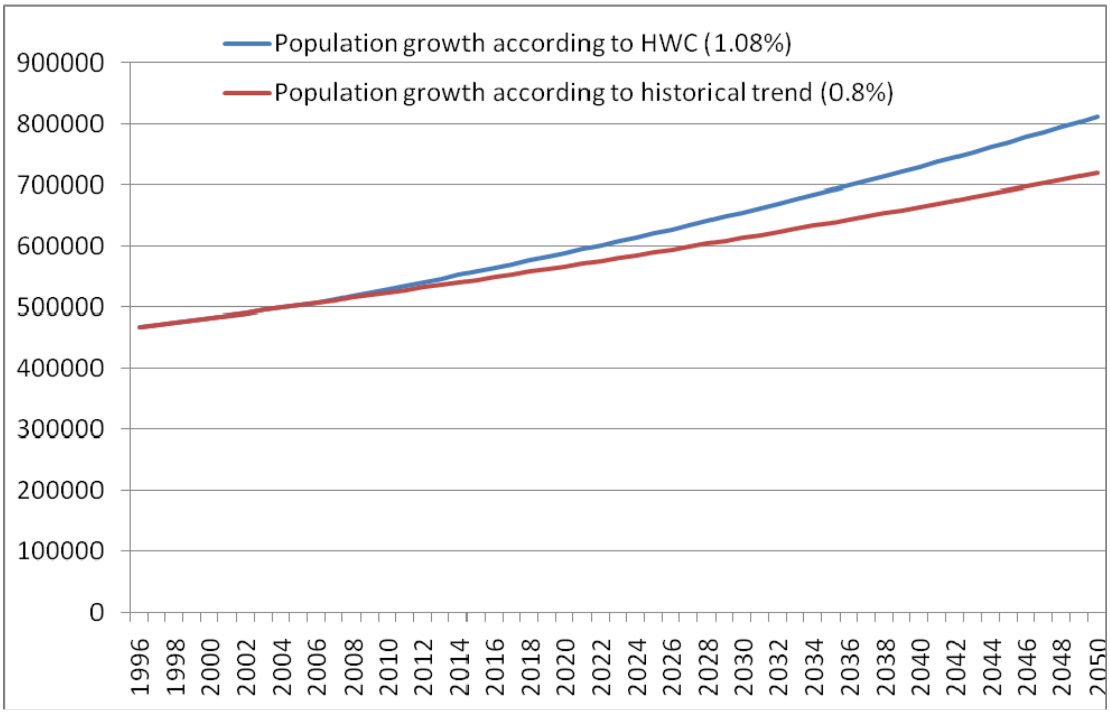
As discussed in Chapter 2, the Gosford-Wyong joint water authority has decided to augment the Central Coast's water supply system through the construction of the 'Mardi to Mangrove' pipeline. This means there is no need for ongoing pumping from the Lower Hunter to the Central Coast (Gosford and Wyong Shire Councils 2007).

Ongoing water demand from the Central Coast should therefore be excluded from demand forecasts for the Lower Hunter.

## 5.6 Population projections

The 2006 Final Lower Hunter regional planning strategy predicted that population will increase by 1.1% a year (or 160,000 by 2031). This was up from 125,000 in the draft strategy and if it occurs would result in an estimated total population of 675,000 by 2031. This population estimate has been simply adopted by Hunter Water in its demand forecasting calculations (Hunter Water Corporation 2007c). However, both the Department of Planning and ABS report that over the past five years population has grown at a rate of 0.8% (see Fig. 4 in the consumption review by Sinclair Knight Merz (2009)). By adopting the higher growth rate, Hunter Water may have significantly overestimated demand for water if this growth does not occur. The difference between the population predictions is shown in Figure 5.3 below.

**Figure 5.3 Population growth estimates for the Lower Hunter**



## 5.7 Improving water demand forecasts for the Lower Hunter

Assumptions made by HWC in their demand forecast modelling, and ISF's suggested improvements, are set out in Table 5-1 below.

**Table 5-1 Assumptions from HWC's water consumption forecast and suggested revisions**

| Identified Issue | Suggested revisions |
|---|---|
| HWC's demand forecast is based on trends in consumption for residential groupings using a broad brush approach | An end-use model should be used to make more accurate assumptions regarding the efficiency of each end use. Alternatively a statistical analysis approach can be used. |
| Historical data has not been corrected for climate using accepted methods and climate data has not been used | Use climate data (rainfall, temp, evapotranspiration) to undertake climate correction using multiple regression |
| Population growth rate of 1.1% per annum assumed | Examine a range of potential growth scenarios, including the historical growth rate which was 0.8% |
| An annual volume of water is assumed to be supplied to the Central Coast | Revise to account for planned infrastructure on the Central Coast - the likelihood of transfers south will be significantly reduced and will not happen every year. |
| HWC assumes that price increases will only affect outdoor residential demand. Water savings assumed from the price increase appear to be underestimated. | Price increases can also be expected to affect indoor demand and non-residential demand. Demand forecast should be amended to account for the sharp increase in the price of water. |
| Planned future demand management has not been included in the demand forecast | Water savings from future demand management needs to be accounted for in the demand forecast |
| The NSW Government BASIX policy to reduce water consumption by 40% has been underestimated. | A 40% reduction in water consumption should be assumed for all new houses in the demand forecast as this is a legislative requirement. |
| Demand from the non-residential sector has been assumed to grow at its current proportion relative to population, despite a significant downward trend in consumption in this sector | The changing economic structure of the region needs to be considered when forecasting demand for the non-residential sector |

# 6 Re-evaluation of the water supply-demand balance in the Lower Hunter

In this section, ISF seeks to investigate the alternatives to the supply and demand forecasts put forward by Hunter Water. Firstly, we put forward alternative yield estimates, as calculated by SKM in their review of Hunter Water's yield model. Following this, ISF presents a high level analysis of demand in the Lower Hunter, using information set out in HWC's 'Why Tillegra Now?' report that improves on Hunter Water's forecast. As described in Section 5, for regional water planning on this scale ISF recommends the development of a demand forecast and options analysis based on end-use modelling and climate corrected data. While the re-evaluation of demand presented in this paper has been undertaken at a high level and does not incorporate end-use analysis, it still offers a more accurate picture than Hunter Water's forecast and shows firstly, that there is ample time available to conduct appropriate water planning in the Lower Hunter and secondly, it demonstrates the potential for water conservation options to significantly reduce demand.

## *6.1 Re-evaluation of supply*

In its review, SKM tested a range of different reliability and drought security criteria to examine the sensitivity of Hunter Water's yield estimate. SKM documented the yield resulting from each of Hunter Water's two original 'level of service' criteria and its new drought security criterion. SKM then tested alternative set of criteria, namely those used by SCA for Sydney's water supply system. SKM's analysis showed the impact of each criterion on yield in the Lower Hunter.

SKM found that HWC's new drought criterion was by far the most limiting in terms of yield and that any other combination of criteria would give a significantly higher yield, in the order of 80–90 GL. The results of SKM's analysis have been reproduced in Table 6-1 below. The first two of Hunter Water's 'level of service' criteria are not in question. However, as discussed in Chapter 4, the assumptions underlying the third criterion are highly questionable and it is therefore important to test the sensitivity of this criterion.

**Table 6-1 Yield Estimates for current Lower Hunter system (Sinclair Knight Merz 2008)**

| No | Criterion | Yield (GL/year) | Used by | History |
|---|---|---|---|---|
| **Reliability criterion** | | | | |
| **1** | One in ten year chance of entering level 1 restrictions | 100 | HWC & SCA & other utilties | Pre 2007, current |
| **2** | Restrictions in place for less than 5% of months over the long term | 90 | Hunter Water & other utilties | Pre 2007, current |
| **3** | Restrictions in place for less than 3% of months over the long term | 81 | SCA | |
| **Drought Security Criterion** | | | | |
| **4** | Probability that storage falls below 5% is 1 in 100,000 months | 107 | SCA | |
| **5** | One in 100 year chance of reaching 4 years storage | 68 | HWC | New, post 2007 |
| **6** | Probability that storage falls below 20% is 1 in 120,000 months* | 85 | N/A – interpolated from data presented | |

**Derived from a one in 10,000 year chance of reaching 20% storages with demand at 85 GL/yr (see Table 10 Sinclair Knight Merz 2008)*

Importantly, when estimating the yield from a water supply system it is the lowest estimate from the set of criteria selected that is seen as limiting and which thereby defines the system yield.

Given this, if the HWC's drought security criterion (no. 5 above) is substituted with Sydney's drought criterion (no. 4), then the limiting criterion in defining system yield for the Lower Hunter would be Hunter Water's second reliability criterion and the system yield is determined as 90 GL/year. This combination of criteria is shown in Table 6-2 below.

**Table 6-2 Yield Estimates for the current Lower Hunter system – extract 1 (Sinclair Knight Merz 2008)**

| No. | Criterion | Resulting Yield (GL/annum) |
|---|---|---|
| **1** | 1 in 10 year chance of entering level 1 restrictions | 100 |
| **2** | Restrictions applied less than 5% of months | **90** |
| **4** | Probability that storage falls below 5% is 1 in 100,000 months | 107 |

As the critical storage level in the Lower Hunter is defined as 10% rather than 5%, it could be argued that Sydney's drought criterion is not conservative enough for the Lower Hunter system. An alternative drought security criterion can however be derived from the analysis presented by SKM in their report (set out in Table 6-1 as no. 6). This criterion has not been used by any water utility, but it is an example of a very conservative drought security criterion for the Lower Hunter. Using this criterion, the yield would be estimated at 85 GL/year. This is set out in Table 6-3 below.

**Table 6-3 Yield assessment for the current Lower Hunter system (Sinclair Knight Merz 2008)**

| No. | Criterion | Resulting Yield (GL/annum) |
|---|---|---|
| **1** | 1 in 10 year chance of entering level 1 restrictions | 100 |
| **2** | Restrictions applied less than 5% of months | 90 |
| **5** | Probability that storage falls below 20% is 1 in 120,000 months | **85** |

A better, less conservative criterion might be that 'the probability that storage falls below 10% is 1 in 120,000 months'. This cannot be tested within the scope of the current analysis however it can be inferred, based on the analysis conducted by SKM that the most reasonable estimate of yield for the current Lower Hunter supply system is in the order of 85 to 90 GL per year.

## *6.2 Re-evaluation of demand*

The water supply-demand balance in the Lower Hunter has been re-evaluated in this chapter in order to highlight two important points. The first point is to show the variance in demand forecasts according population and the second point is to show the impact of demand management programs. It must be emphasised that the forecasts undertaken here use a broad brush approach, improving on those used by HWC. The intention here is to show the sensitivity of the forecasts and to show how demand might be significantly reduced through a concerted demand management campaign.

## *6.3 Demand forecast using HWC's assumptions*

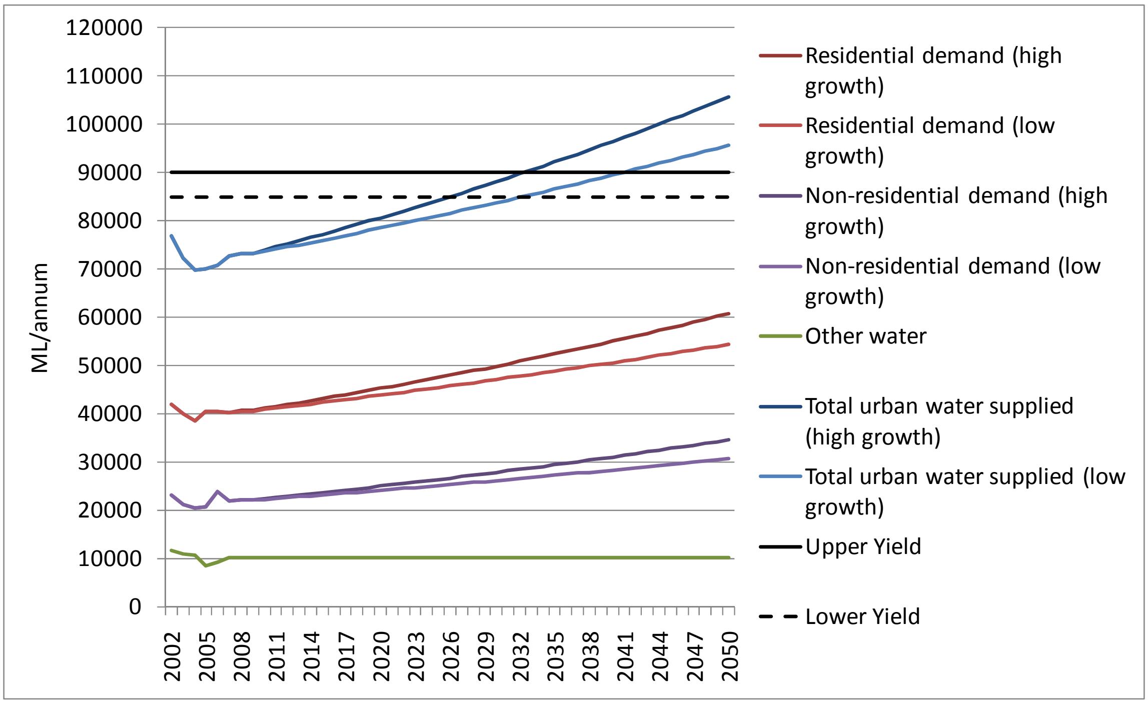
To begin with, the assumptions used by HWC in their demand calculations have been used in order to replicate HWC demand forecasts so that this forecast can be compared with others. This projection is shown in Figure 6-1. In this graph, data from the National Water Commission has been used to show historical water demand from 2002 to 2005 and Hunter Water's consumption figures from 'Why Tillegra Now?' have been used for 2006. Key assumptions used to replicate HWC's demand include:

- Population was assumed to increase at 1.08% p.a. for the high growth scenario and at 0.8% for the low growth scenario
- Non-residential water use was assumed to increase with population based on historic pro-rata water consumption (0.043 ML/capita/year)

- Water use in 2007 was assumed to be an average of the preceding 5 years, using both NWC and HWC data. Actual 2007 data was not used as HWC did not use it.
- ‘Other water’ use was assumed to stay at 10.3 GL/year
- A 26% reduction in water consumption was applied for new dwellings (see earlier discussions on HWC’s calculations regarding BASIX)
- Occupancy rates of 2.5 and 2.0 have been used for detached and multi-residential dwellings respectively
- The proportion of detached housing to multi-residential housing was assumed to be 65:35, as stated in ‘Why Tillegra Now?’ (Hunter Water Corporation 2007c).

Figure 6-1 shows that by adding sensitivity to assumptions regarding population growth into the demand projection, the forecasts of the total demand vary by 5 GL in 2030 and by 10 GL in 2050. This projection shows that if population increases at a rate of 1.08%, then total demand might reach 80 GL in 2020 and 90 GL in 2033. Note that this demand projection does not include any demand management programs as SKM reported that no future demand management programs were included in the HWC forecast (Sinclair Knight Merz 2009).

**Figure 6-1 Forecast demand in the Lower Hunter as determined by HWC**




## *6.4 Demand forecast amended to reflect recommended improvements*

A new demand forecast was developed using consumption data from the NWC for the years 2002-2007. This forecast is different because HWC’s reported consumption for 2006 was higher than that reported by NWC and HWC did not use 2007 data in their forecast. The 2008 consumption was then set as an average of these preceding years and demand was forecast from 2008 to 2050.

This forecast has also corrected two major elements. Reductions in residential water use due to BASIX have been increased from 26% to 40% and the growth in non-residential demand has been adjusted.

While Hunter Water has assumed a 26% reduction in demand at new residential dwellings due to BASIX, BASIX legislation requires a 40% reduction in water use. Hence, in the following demand projection, a 40% reduction has been applied to the water demand for new residential dwellings (both detached and multi). See Figure 6-2a and 6-2b.

In Figure 6-1, historical non-residential water use was used to project future non-residential water use. However, non-residential demand in the Lower Hunter has been falling in both total and proportional terms over several decades. Given this, new growth in non-residential water use proportional to population growth is much more likely to approach the ratio in Sydney – which is 0.030 ML/capita/year, rather than be the same as the historically high levels in the Lower Hunter (0.043 ML/capita/year). The growth of non-residential water use has been corrected to account for this in the following projection in Figure 6-2a and Figure 6-2b below.

This projection provides a reasonable base case for water demand in the Lower Hunter. Based on this forecast, water demand reaches 80 GL in 2026 and 90 GL in 2042 for the high population scenario. However, this scenario still does not include any substantial demand management programs.

**Figure 6-2a Base case demand forecast for the Lower Hunter – corrected for BASIX reduction and growth in non-residential water use**

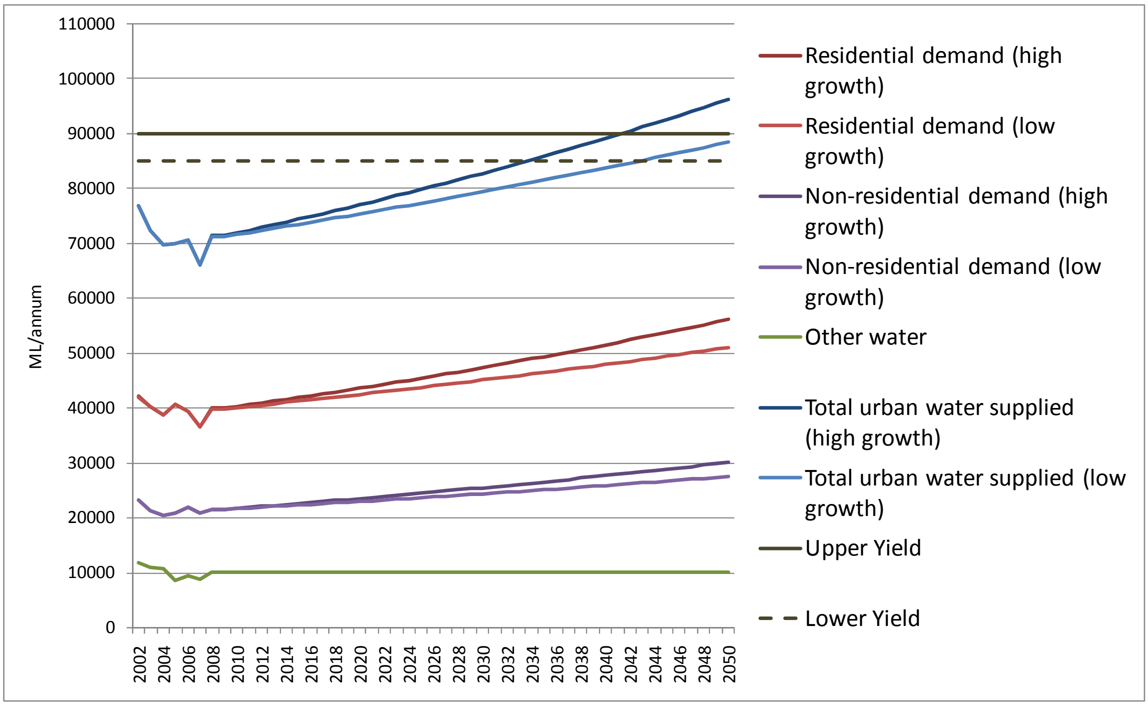
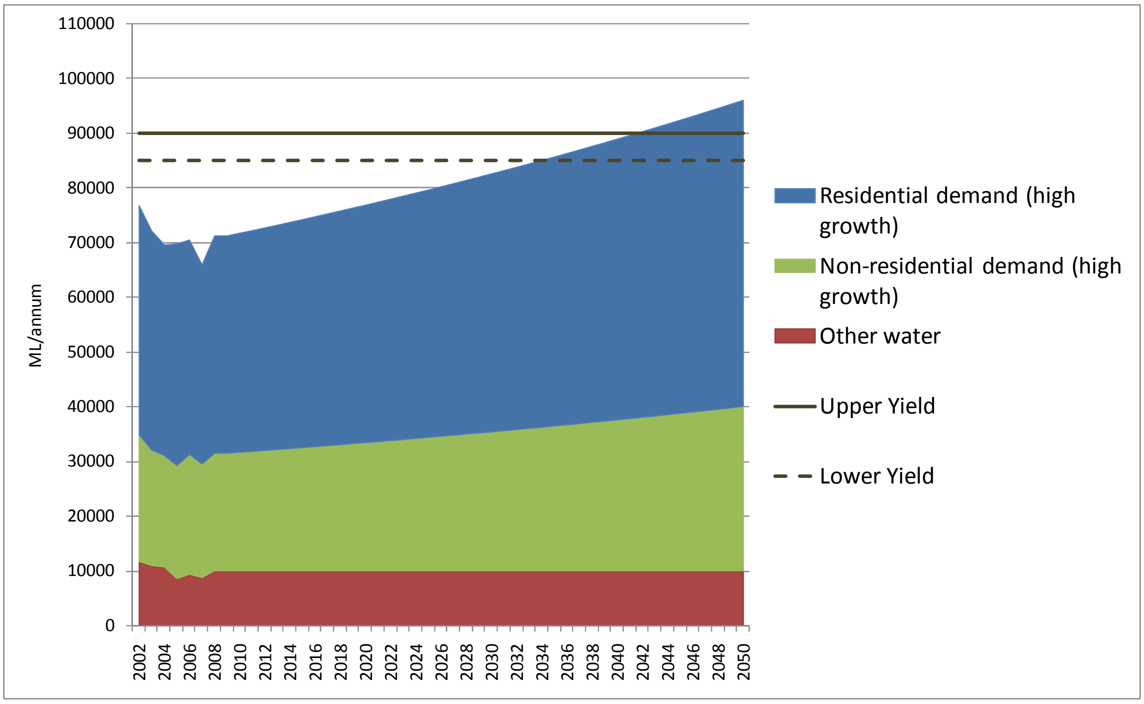


**Figure 6-3b Base case demand forecast for the Lower Hunter – corrected for BASIX reduction and growth in non-residential water use (high population growth only)**




## *6.5 Demand forecast with a concerted campaign to manage demand*

In this third forecast, the baseline demand set out in Figure 6-2a and b has been used to develop a vision for water management in the Lower Hunter with a concerted campaign to manage demand. To do this, ISF has apportioned Sydney Water demand management program savings on a per capita basis and applied it to the Lower Hunter. This then represents an actual program that has for the most part already been implemented and for which water savings have been verified (Sydney Water 2008).

ISF's analysis used the water savings that have been made by each of Sydney Water's demand management programs as well as forecast water savings due to future demand management programs. Savings from leakage and pressure reduction as well as re-use have been excluded. The data has been used to determine the potential water savings per capita due to demand management for the residential and non-residential sectors. These water savings figures have been applied to the Hunter Water population figures to determine how much water might be saved by Hunter Water if it was to undertake a similar demand management campaign but on a scale proportional to its smaller population. Given that the current per capita water consumption in the Lower Hunter is above Sydney's (accounting for residential and non-residential water use) these savings should be considered conservative estimates.

The projected savings are shown in Figures 6-3a and 6-3b. Using this approach, if HWC were to follow Sydney Water's lead then water demand in the Lower Hunter would reach 80 GL in 2046 in a high population growth scenario, and in a low growth scenario, demand would not reach 80 GL within the timeframe.

**Figure 6-3a Demand forecast with demand management similar to Sydney Water's existing program, showing both high and low population growth**

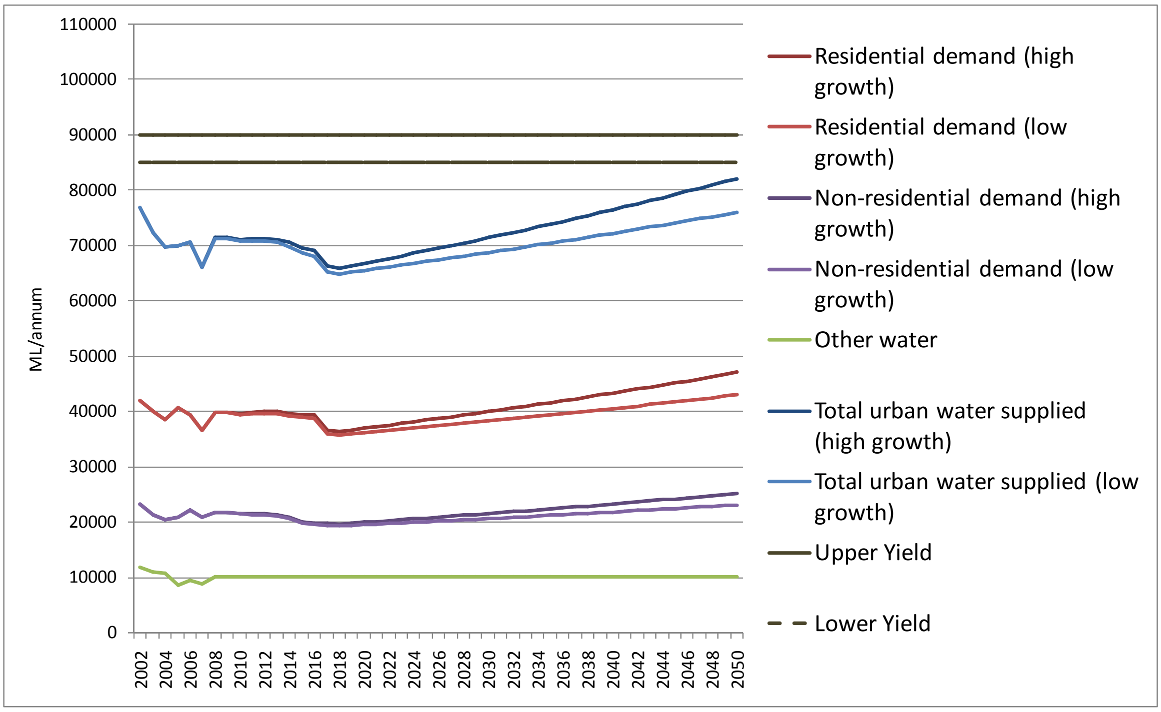
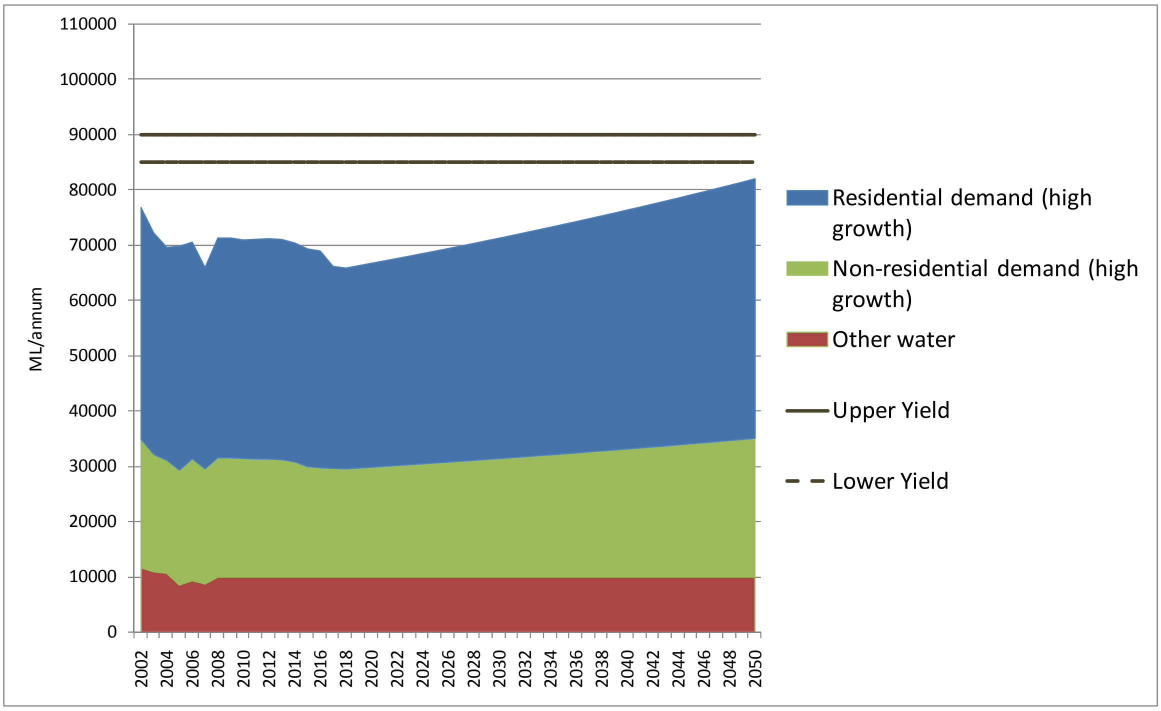



**Figure 6-3b Demand forecast with demand management similar to Sydney Water's existing program (high population growth only)**




These forecasts show that with a concerted demand management program, demand in the Lower Hunter could be reduced well into the future. If this was the case a supply augmentation would still not be required until after 2050.

# 7 Towards an alternative water supply-demand strategy for the Lower Hunter

The re-evaluation of future water demand and available water supply in Chapter 6 above demonstrates that the Lower Hunter is far from being in an emergency situation with regard to long-term water supply, and nor is there a concern with drought security. The spare capacity that exists between actual consumption levels and available supply (including system drought security) has in fact been increasing over several decades.

Significant time is therefore available for a full, open and integrated sustainable urban water process including genuine community engagement and consideration of all the options. Based on its significant experience in supply-demand planning across Australia and internationally, ISF believes that the following elements are needed to establish a sustainable urban water strategy for the Lower Hunter that the public will support. These are:

1. Consideration of all the options
2. Demand management and water reuse
3. Drought readiness
4. Community involvement in key decisions in urban water.

## *7.1 Consideration of all the options*

Sustainable water supply planning requires equal consideration of demand management strategies, water re-use strategies and supply options of various sizes. This principle of equal consideration for both demand and supply was a requirement of IPART on Hunter Water for its 2003 Integrated Water Resource Management Plan (IWRP). It was also embedded within the Sydney Metropolitan Water Planning process, and is central to the Integrated Water Cycle Management process required of regional water supply authorities by the NSW Department of Water and Energy.

The NSW Government issued a directive to IPART preventing it from investigating or reporting on whether the decision to build the Tillegra Dam meets this basic requirement. Hunter Water's latest planning document (the 'H250 Plan') specifically excluded consideration of alternatives to the Tillegra Dam. In the 'Why Tillegra Now?' report, the only other options considered were other inappropriately large supply alternatives.

HWC needs to thoroughly investigate all the alternatives and give proper attention to the water savings that can be gained through demand-side initiatives. In addition, the NSW Government needs to remove its directive to IPART and allow the tribunal to undertake its normal job in assessing the need for new infrastructure and its cost to the community.

## *7.2 Demand management and water re-use*

As part of considering all options, demand management and water conservation need to be taken seriously in water supply-demand planning for the Lower Hunter and they need to be funded appropriately.

Cost-effective measures that are currently *not in place in the* Lower Hunter *unlike Sydney and other large Australian cities include*:

- Long-term water savings rules or 'water wise rules'
- Mandatory water savings action plans for high users
- Washing machine rebates for residents
- Business and other non-residential water savings programs
- An ongoing residential retrofit program.

If taken seriously, water conservation and demand management have major roles to play in water supply-demand planning for the Lower Hunter. These measures are not only cost effective, but can be undertaken incrementally to meet rising demand. The risk-weighted cost of such measures is negligible compared to the cost of building large supply-side infrastructure which is likely to be largely redundant.

Wastewater re-use and rainwater and stormwater harvesting should also be considered in all new residential and non-residential developments. For example, there is the potential for new residential developments to significantly improve on BASIX if both dual reticulation and rainwater tanks are included. Analysis of these options needs to account for the flexibility that is afforded by smaller-scale supply options that meet demand as it occurs. Incremental investment represents a significantly lower financial risk than a large-scale supply augmentation that is designed to supply projected demand many decades into the future.

## *7.3 Drought readiness*

There is currently just a one in one million year chance of reaching critical storage levels, and a robust drought management plan including a drought contingency plan can be developed for the Lower Hunter to avoid this extremely small risk.

As WSAA Occasional Paper 14 states, 'it is expected and understood that water utilities manage their water resources so that communities never run out of water' (Erlanger & Neal 2005) and that is what a drought management plan does for a region.

A drought management plan should be a central component in the region's sustainable urban water strategy and should draw on current industry practice in relation to contingency planning including 'readiness' or 'ready to construct' options. Although this type of planning has been developed in regions with significant climate change concerns, it is still relevant to the Lower Hunter. Common drought readiness options include accessing unutilised groundwater and desalination.

Taking a readiness approach means preparing all the planning and approvals for an option before a drought occurs. Readiness should also include selecting a site for any plant that is required and may also include purchase of the site.

The key idea of this approach is to prepare as much as possible for the implementation of a drought contingency option, without actually starting construction. This approach significantly reduces the time required to carry out that option and hence reduces the likelihood of ever reaching the trigger point where construction is actually required. This approach prevents the scenario in a drought situation where the planning process is triggered and by the time construction begins, the option is no longer required.

Analysis of repeat drought sequences can then be used to determine which storage level in an extreme drought should serve as a trigger for construction (making the highly conservative assumption that the drought might continue indefinitely).

The reason for this level of preparation is shown in Hunter Water's own analysis of lead times during a drought sequence. It shows that for each month that construction times can be reduced by pre-planning and pre-construction, there is a dramatic reduction in the likelihood of actually needing to start construction.

An extract of Hunter Water's analysis is shown in Table 7-1 below, where set lead times for constructing a contingency option are shown in the left-hand column and the corresponding storage trigger is shown in the central column. The probability of reaching the storage trigger point is then shown in the column on the right-hand side.

A range of lead times is shown in Table 7-1 to illustrate how adjustments to the lead times – through adequate drought readiness planning – can minimise the likelihood of triggering a drought contingency option.

**Table 7-1 Influence of lead times on triggering drought contingency options (Hunter Water Corporation 2007a)**

| Time available for construction before reaching 10% storage | Storage trigger for construction with demand at 80GL | Annual probability of reaching trigger level |
|---|---|---|
| 36 | 46% | 1 in 130 |
| **30** | **35%** | **1 in 600** |
| 24 | 25% | 1 in 3,000 |
| 18 | 19% | 1 in 20,000 |

(Figures drawn from HWC closed board report 28/6/2007)

HWC's 2006 drought management plan assumed an 18-month lead time to build a desalination plant and in closed board reports prepared after the dam was announced; a 36-month lead time was referred to, while in documents justifying the dam, this lead time grew to 48 months (including planning). The Sydney metropolitan plan assumed 26 months would be sufficient to construct a desalination plant. It should be noted that the potential location of the drought contingency desalination plant at Stockton relative to the Grahamstown Dam means that its construction would be far simpler than Sydney's desalination plant at Kurnell.

ISF believes that with substantive planning, the construction time required for a desalination plant in the Lower Hunter could be reduced to less than 30 months. This would reduce the chance of triggering construction of the desalination plant to once in 600 years. Such an approach would however require planning, approvals and preconstruction to occur now with the ensuing cost. This cost is likely to be in the order of $70 to $100 million based on HWC figures (Hunter Water Corporation 2007c).This is significantly less than the financial cost of the dam and would entail none of the social and environmental costs.

## *7.4 Community involvement in key decisions in urban water*

Another key component of sustainable urban water planning is community involvement. As stated previously, the Tillegra Dam will set the Lower Hunter community up for high water prices that will increase into the future. As discussed throughout this paper, Tillegra Dam is certainly not a necessity – and definitely not the only option. The community ought to be consulted to determine the level of service they require and are willing to pay for.

An alternative strategy might include: demand management programs, retrofits, rainwater tanks, wastewater recycling and other non-residential programs and readiness options. However, in order to develop an alternative strategy, a detailed demand forecast and a comprehensive assessment of the alternatives need to be carried out in the presence of a full and open public engagement process. As our review highlights, the Lower Hunter is not in an emergency situation and there is plenty of time to develop a sustainable water management strategy.

# 8 Conclusions and recommendations

The review of the Lower Hunter's existing water supply system and associated documentation finds that:

- The reduction in the estimated capacity of the existing system which occurred in 2007, after the Tillegra Dam was announced, is unwarranted. It does not reflect the actual performance of the supply system and is based solely on the introduction of a new drought criterion into the calculation of system yield. This new criterion contains flawed and arbitrary assumptions.
- Consequently, the available supply from the existing system should be considered to be 90 GL per year. This figure is arrived at by applying industry standard drought security and reliability criteria.
- The level of drought security in the Lower Hunter was found to be at a 30-year high. This is because water demand decreased over that period while storage volumes have increased. Hunter Water's modelling showed that there is only a one in a million chance of reaching critical supply levels in any given year.

The review of water consumption and demand forecasts in the Lower Hunter finds that:

- Water consumption in 2007/08 was 67 GL, the lowest recorded for 40 years and the average consumption over the past five years was 70 GL per year
- Hunter Water's demand forecasts are simplistic and significantly overestimate future water demand.
- Hunter Water's forecasts do not account for, or underestimate, the impact of factors that will significantly reduce demand. These include: the NSW Government BASIX policy, the water savings from demand management and recycling initiatives, decreasing water use due to increasing water prices, the changing proportion of residential to non-residential water use, and the impact of the decreased likelihood of water transfers from the Lower Hunter system to the Central Coast.
- Realistic projections of water demand in the Lower Hunter remain well below the available supply from the existing system for many decades to come.

Taken together, the reviews of water supply and demand in the Lower Hunter indicate that there is more than sufficient time to expand on demand management initiatives and develop a sustainable urban water strategy before any new supply options need to be considered.

## Recommendations

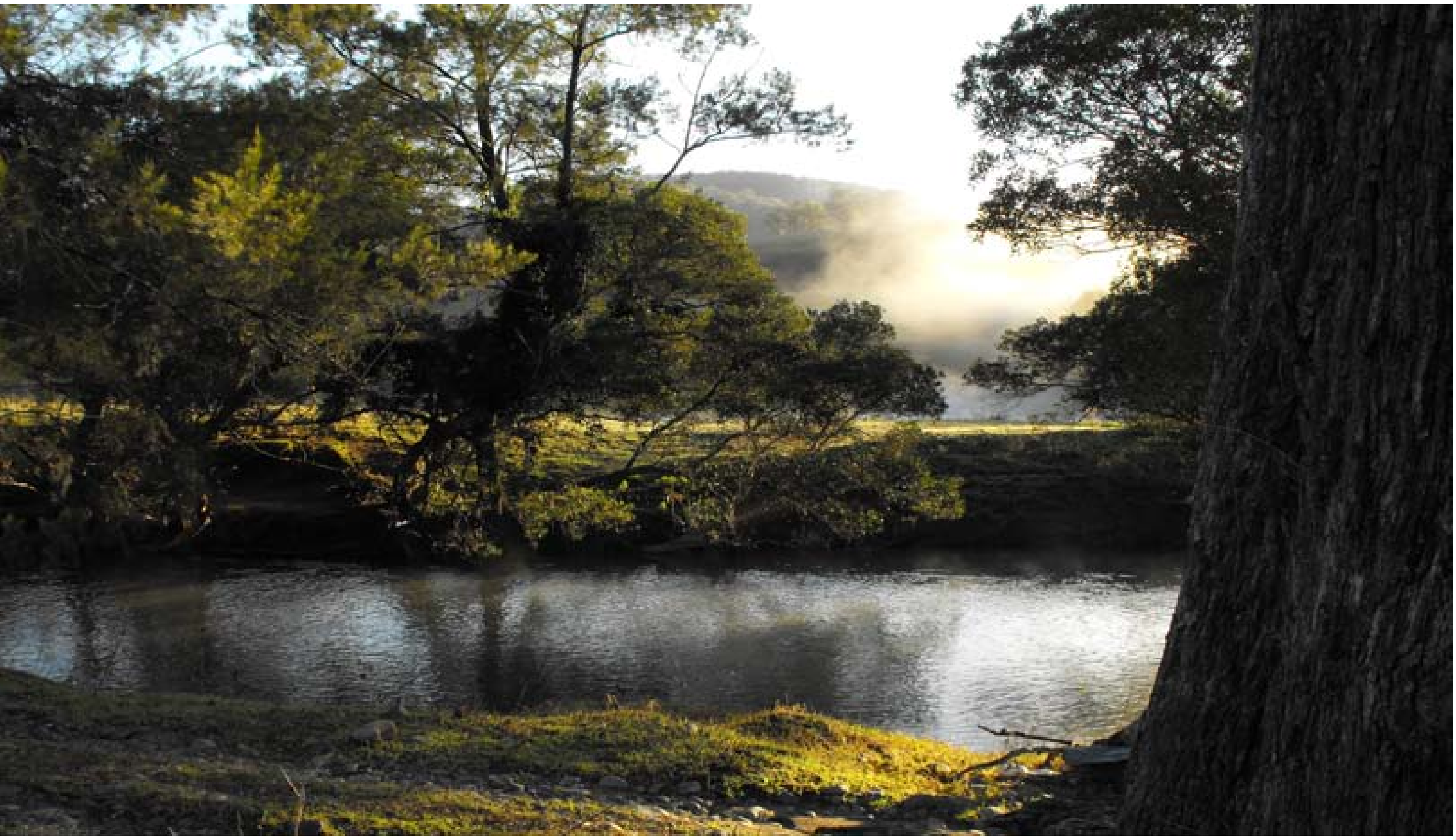
This report recommends that:

1) the NSW Government direct Hunter Water to immediately halt all planning and construction activities for building the Tillegra Dam
2) the NSW Government revoke its directives to IPART concerning the Tillegra Dam and allow the economic regulator to assess the need for the dam. IPART should then reconsider its price determination for the Lower Hunter unencumbered

3) Hunter Water should adopt standard industry practice with respect to estimating its available water supplies
4) Hunter Water should adopt demand forecasting that reflects industry practice for water utilities of a similar scale across Australia
5) a full and open integrated water resource planning process to develop sustainable urban water strategy for the Lower Hunter should be instigated
6) this process should include genuine public engagement on all key urban water decisions and consideration of all the options.

# 9 References

Benson, S. 2006, '$342m for dam in Hunter', *Daily Telegraph*, November 13, 2006.
Department of Planning 2006, *Lower Hunter Regional Strategy*, NSW Government.
Erlanger, P. & Neal, B. 2005, *Framework for Urban Water Resource Planning - Occasional Paper no. 14*, Water Services Association of Australia
Goodwin, I. & Blackmore, K. 2009, *Hunter, Central and Lower North Coast Regional Climate Change Project: Fact Sheet - Research methodology and findings*, University of Newcastle, HCC REMS, NSW Government.
Gosford and Wyong Shire Councils 2007, *Water Plan 2050: A long-term water supply strategy for the Central Coast*.
Hunter Water Corporation 2003, *Integrated Water Resource Plan*.
Hunter Water Corporation 2006, *Integrated Water Resource Plan: Report to IPART*.
Hunter Water Corporation 2007a, *Closed Board (Confidential): Change to DMP following revised environmental approval and desalination timeframes (28.7.2007)*, in B. Berghout (ed.).
Hunter Water Corporation 2007b, *Closed Board (Confidential): Definition of Yield (26.7.2007)*, in B. Berghout (ed.).
Hunter Water Corporation 2007c, *Why Tillegra Now?*
Hunter Water Corporation 2008a, *$H_2$50 Plan - Securing our water future: A long term strategy to meet water supply needs for the Lower Hunter*.
Hunter Water Corporation 2008b, *Integrated Water Resources Plan: Report to IPART*.
Hunter Water Corporation 2008c, *Submission to IPART on prices to apply from 1 July 2009*.
Independent Pricing and Regulatory Tribunal NSW 2009a, *Gosford City Council and Wyong Shire Council: prices for water, sewerage and stormwater drainage services from 1 July 2009 to 30 June 2013 - Determinations and Final Report*.
Independent Pricing and Regulatory Tribunal NSW 2009b, *Review of prices for water, sewerage, stormwater and other services for Hunter Water Corporation: Water - Determinations and Final Report*.
Independent Pricing and Regulatory Tribunal NSW 2009c, *Review of prices for water, sewerage, stormwater and other services for Hunter Water Corporation: Water - Draft Determination and Draft Report*.
Kuczera, G. 2008, *Review of the Hunter Water Corporation Approach to Assessing System Yield*, University of Newcastle Research Associates.
NSW Department of Water and Energy 2008, 'Report Card for Williams River Water Source', personal communication, March 2008.
Queensland Water Commission 2008, *South East Queensland smashes water consumption record - Media Release 11/7/2008*, <http://www.qwc.qld.gov.au/tiki-read_article.php?articleId=255>.
Ray, G. 2009, 'A matter of politics', *Newcastle Herald*, Saturday, January 3rd 2009.
Rhodes, B. & Yurisich, R. 2008, *Comments on Report 'Why Tillegra Now?' Hunter Water*, Melbourne Water - Urban Water Planning.
Rubeli, K. 2008, *A preliminary study of platypus population and distribution along a section of the Upper Williams River*, LightFoot Foundation.
Sinclair Knight Merz 2008, *Review of Yield Estimates: Review of Yield Estimates for Hunter Region - Final Report*, prepared for IPART.
Sinclair Knight Merz 2009, *Review of Water Consumption Forecasts: Review of water consumption forecast in Hunter Water Corporation's 2008 submission to IPART on prices to apply from 1 July 2009 - Final*, IPART.
Sydney Water 2008, *Water Conservation and Recycling Implementation Report*.
White, S., Campbell, D., Giurco, D., Snelling, C., Kazaglis, A. & Fane, S. 2006, *Review of the Metropolitan Water Plan: Final Report*, UTS, ACIL Tasman.
Young, K. 2006, 'Re: Follow up notes on major water resource projects', personal communication, 28 September 2006.



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