KEY TERMS

TERM	DEFINITION
BASIX	A planning tool developed by the NSW Government that is used by development applicants to measure their compliance with environmental guidelines covering water and greenhouse gas efficiency and other related building aspects. Required for building and renovation approval.
Bulk water production	Water supplied for use. Bulk water production amounts differ from consumption by the amount of water that is lost within the distribution system.
Consumption	Use of water for domestic, industrial, agricultural, irrigation and commercial use. Water consumption is recorded at the site of use and therefore does not include water lost within the distribution system.
Demand management	Measures, programs or strategies aimed at reducing the consumption of water by reducing the demand for it.
DSS	Demand Side Management Decision Support System. Model used to project water consumption and wastewater production patterns, and the impact of water consumption demand management options.
Equivalent Persons (EP)	The water supply demand or the quantity and/or quality of sewage discharge for a person resident in a detached house.
Greenfield Development	New development that occurs in areas that have not previously been developed (e.g. recently cleared land).
Greywater	Wastewater from the hand basin, shower, bath, spa bath, washing machine, laundry tub, and dishwasher.
Infill development	Infill development refers to new residential development in developed areas. This is often also referred to as brownfield development.
Rainwater tank	Storage tank for collecting rainwater from the roofs of buildings.
Recycled/ reclaimed water	Sewage effluent or treated stormwater that has been treated to a level where it can be reused.
Reuse	The use of treated sewage effluent or treated stormwater to replace the use of potable water.
Source substitution	The use of treated sewage effluent or treated stormwater to replace the use of potable water.
Unaccounted For Water (UFW)	Water that appears to be lost or illegally taken from a water supply scheme. Unaccounted For Water is often identified where there are significant differences between production and metered consumption records.
WATHNET	Bulk water supply model used to estimate bulk supply levels and security, based on changes in climate and water consumption.
WELS	Water Efficiency Labelling and Standards Scheme introduced by the Australian Government.

The preparation of climate dependent water demand forecasts for the CENTROC Water Security Study involved the use of the demand side management decision support system (DSS) and the PURRS model and compilation framework.

This project has successfully utilised long climate records, socio-economic information, the DSS and continuous simulation methodologies to generate water demand sequences for input to the network linear program WATHNET. The analysis has incorporated water efficient appliances and rainwater tanks in scenarios that relate to the BASIX legislation and in a scenario with extended demand management efforts.

The results from this analysis show the expected variation of water demands in response to climate variation and climate change that are important for the analysis of water security. A strategy to include water efficient appliances and rainwater tanks in towns, in accordance with BASIX legislation, will make a significant contribution to mitigating the impacts of climate change.

B.1 INTRODUCTION

This Appendix provides an overview of the process of developing climate dependent water demand forecast across the CENTROC region as part of the CENTROC Water Security Study.

The preparation of climate dependent water demand forecasts involved two distinct processes:

- Use of the demand side management decision support system (DSM DSS), which includes:
    - Analysis of historical demand records. Assessment of the influence of climate, water restrictions and water tariff structures. Identification of these drivers for change allows an assessment of the underlying trends in consumption;
    - Preparation of demand forecasts, based on:
        - Population growth projections;
        - Historical trends in household size;
        - Trends in the uptake of efficient fixtures and appliance;
        - Recorded and projected impact of demand management programs.
- Use the PURRS (Probabilistic Urban Rainwater and Wastewater Reuse Simulator) model and compilation framework to:
    - Incorporate results from the DSS in a climate dependent framework that includes household indoor and outdoor use and other water use for each town
    - Translate the average results from the DSS, including demand management outcomes, to generate long sequences of climate dependent water uses for each demand node used in WATHNET
        - The process utilises distributions of household sizes and long sequences of historical cl0.imate from each location
        - The actual distribution of household sizes at each location are also recognised in the simulation framework
    - Utilise climate dependent algorithms for other water uses including commercial, industrial, system losses and unaccounted for water uses
    - Use climate replicate sequences including climate change scenarios to generate sequences of water use at each town.

B.2 METHODOLOGY

The process of developing forecasts of climate dependant water demands combining the use DSM-DSS and PURRS models consisted of three main steps.

First, the DSS model forecasted annual water use for different water sectors (residential, commercial, industrial and other), based on historical water use, distribution of household appliances and population.

Second, the historical climate data from each location was used to create synthetic pluviograph records which were combined with distributions of households sizes, temperature and water use from the DSS in the PURRS (probabilistic urban rainwater and wastewater reuse simulator) model. The PURRS models for each location were calibrated using annual water use results from the DSS. The annual water demands from the DSS at each location were then translated into sets of households with no, low, moderate and high water use efficiency for use in simulations using PURRS. The analysis also considered the distributions of household sizes at each location.

Climate dependent models of urban non-residential water use (Other) were created for each location and calibrated using average water demands from the DSS. The results from the PURRS simulations were then sampled using non-parametric climate techniques that utilise daily temperature, daily rainfall and antecedent dry days in the PURRS results and in the climate replicates generated using WATHNET to assign the most likely water demand at each time step. The water demands generated by PURRS were verified using the DSS results for each town.

Finally the residential and other water demands at each location were combined to generate replicates of water demand. The expected impacts of climate change in the Lachlan and Central West catchments includes increases in temperature from 0.7°C to 5.6°C and changes in rainfall from +20% to -40% by 2070[1]. Climate replicates were also generated that account for the maximum predicted incremental changes of temperature in the catchments by 2070. These climate replicates were generated by sampling the historical relationship between trends in rainfall and temperature, and then applying these trends to the increased temperature regime associated with climate change in accordance with latest advances in non-parametric sampling techniques[2,3]. The replicates of climate change were used to generate water demands that could be expected during climate change.

A schematic description of the DSM-DSS and PURRS models use for demand forecast is shown in

Figure B-1.

[1] CSIRO (2007) Climate change in the Lachlan and Central West Catchments.

[2] Frost A.J., Mehrota R, Sharma A and Srikanthan R. (2006). Comparison of statistical downsizing techniques for multi-site daily rainfall conditioned on atmospheric variables for the Sydney Region. Proceedings of Water Down Under. Engineers Australia. pp. 471 – 482.

[3] Coombes P.J., M. Thyer, A. Frost, G. Kuczera and I. Grimster (2003). Development of stochastic multisite rainfall and urban water demand for the Central Coast Region of New South Wales. 28th Hydrology and Water Resources Symposium. Engineers Australia. Wollongong. NSW.

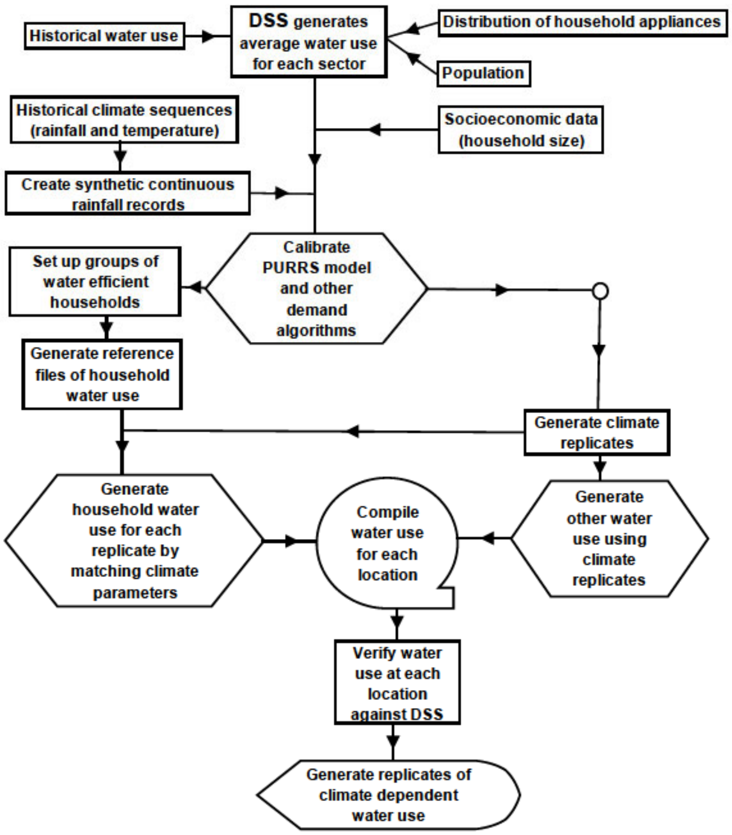

Figure B-1: Flow chart of the process to develop climate dependent water demands

B.3 DEMAND MANAGEMENT SCENARIOS

Water conservation programs are likely to reduce future water demand. Therefore, to accurately forecast water demand, it is necessary to take into account the potential impact of demand management practices under the different strategic options. For the CENTROC demand forecast study, three different demand forecast scenarios have been prepared (Table B-1).

Table B-1: Demand Management Scenarios

DEMAND MANAGEMENT SCENARIO		DESCRIPTION	DEMAND MANAGEMENT OPTIONS
1	Base Case	Projection of consumption behaviour, including the expected changes in the uptake of efficient fixtures, appliances and fittings resulting from changes in market availability.	• Baseline – No options modelled.
2	Current Programs	Current Programs: Takes into account the demand management programs in place that are typically being implemented by Councils within the CENTROC Water Supply Security Study Area.	• WELS • Residential Retrofit • BASIX • Education – Water Conservation • System Water Loss Management • 25:75 Fixed: Variable Charge Ratio

DEMAND MANAGEMENT SCENARIO		DESCRIPTION	DEMAND MANAGEMENT OPTIONS
3	Maximum Conservation	Includes additional programs considered likely to be cost effective for Councils within the CENTROC Water Supply Security Study Area.	• WELS • Residential Retrofit • BASIX • Education – Water Conservation • System Water Loss Management • 25:75 Fixed: Variable Charge Ratio Non – Residential Audit • Permanent Low Level Restrictions

Each scenario has been forecasted based on the same population growth rates and household size trends. The methodology described above has been applied consistently for each of the three scenarios.

B.3.1 DEMAND MANAGEMENT OPTIONS

Table B-2 sets out a description of the demand management options that were incorporated into Demand Management Scenario 2: Current Programs (Business as Usual) and Demand Management Scenario 3: Maximum Conservation.

Table B-2: Demand Management Options

OPTIONS		DESCRIPTION
1	Residential Retrofit	Replacement of inefficient shower heads, taps and sinks with more flow-efficient fixtures. The program includes supporting customers in replacing fixtures and fittings.
2	WELS	Continuation of the Federal Government's Water Efficiency Labelling and Standards Scheme (WELS).
3	Permanent Low Level Restrictions (Outdoor)	Implementation of permanent restrictions on outdoor water use.
4	BASIX	Continuation of the State Government's BASIX program for new developments.
5	Education – Water Conservation	Continuation or expansion of water conservation education programs aimed at improving efficiency in water use.
6	Non-Residential Audit	Audit of water use in non-residential properties. The purpose of the audit is to identify leaks and potential areas for improvement in water efficiency.
7	System Water Loss Management	Review of water supply and distribution system to identify and repair leaks.
8	25:75 Fixed to Variable Charge Ratio	Review of pricing structure for water supply and sewerage services provided by LWUs to fully recover the cost of their provision. The DWE Best Practice Guidelines require that 75% of service provision costs be recovered from the variable charge component and 25% from the fixed charge component.

B.3.2 MODELLED DEMAND NODES

In order to develop an understanding of future water demands within the CENTROC study area, the region was divided into demand nodes within each water supply scheme. Table B-3 below outlines the demand nodes that were modelled in the demand forecast process.

Table B-3: Modelled Demand Nodes

DEMAND NODE	WATER SUPPLY SCHEME	LWU / COUNCIL	TOWNS / CENTRES INCLUDED
Bathurst	Bathurst	Bathurst Regional Council	Bathurst (Urban Centre Locality). Rural/ Residential areas outside of centre excluded
Blayney - Carcoar	Central Tablelands Water	Blayney Shire Council, Bathurst Regional Council	Blayney, Millthorpe, Carcoar, Lyndhurst, Mandurama, Garland
Boorowa	Boorowa	Boorowa Council	Boorowa
Canowindra	Central Tablelands Water	Cabonne Shire Council	Canowindra, Woodstock
Condobolin	Lachlan	Lachlan Shire Council	Condobolin
Cowra - Koorawatha	Cowra	Cowra Shire Council, Young Shire Council, Weddin Shire Council	Cowra, Koorawatha, Bendick Murrell, Brundah, Greenethorpe, Mogongong, Wattamondara
Crookwell	Upper Lachlan	Upper Lachlan Council	Crookwell
Cudal/ Cargo/ Manildra	Central Tablelands Water	Cabonne Shire Council	Cudal, Cargo, Manildra
Cumnock - Yeoval	Cumnock	Cabonne Shire Council	Cumnock, Yeoval
Forbes	Forbes	Forbes Shire Council	Forbes (Urban Centre Locality). Rural/ Residential areas outside of centre excluded
Gooloogong-Eugowra	Central Tablelands Water	Cowra Shire Council, Cabonne Shire Council	Gooloogong, Eugowra
Grenfell	Central Tablelands Water	Weddin Shire Council	Grenfell
Lake Cargelligo	Lachlan	Lachlan Shire Council, Tullibigeal	Lake Cargelligo, Murrin Bridge, Tullibigeal
Lithgow - Portland	Fish River, Lithgow	Lithgow Shire Council	Lithgow and Portland
Molong	Molong	Cabonne Shire Council	Molong
Murrumburrah (Harden)	Harden, Goldenfields Water County Council	Harden Shire Council	Galong, Murrumburrah, Jugiong, Wombat
Oberon	Oberon	Oberon Council	Oberon, Oberon timber industry
Orange	Orange	Orange Shire Council	Orange, Clifton Grove
Parkes	Parkes	Parkes Shire Council	Parkes, Peak Hill, NorthParkes Mine
Wellington - Geurie	Wellington	Wellington Council	Wellington, Geurie, Nanima
Young	Young	Young Shire Council	Young. Rural/ Residential areas outside of centre excluded

B.3.3 UNMODELLED POPULATION CENTRES

A number of towns and other population clusters were excluded from the study due to their small contribution to the overall demand. A comprehensive list of the demand nodes excluded from the model is shown is Table B-4.

Table B-4: Demand Nodes Excluded from Modelling

DEMAND NODE	LOCAL WATER UTILITY	EXPLANATION
Baldry	Baldry	Rainwater fed supply
Barry	Barry	Rainwater fed supply
Bedgerebong	Bedgerebong	Minor stand-alone surface water supply system
Billimari	Bilimari	Minor groundwater supply system
Bimbi	Bimbi	Rainwater fed supply
Birriwa	Birriwa	Not in study area
Bribbaree	Bribbaree	Rainwater fed supply
Burcher	Burcher	Rainwater fed supply
Burraga	Burraga	Minor stand-alone surface water supply system
Caragabal	Caragabal	Not in study area
Caves Caravan Park	Caves Caravan Park	Minor groundwater supply system
Westville	Central Tablelands Water	Minor surface water supply system
Cobar	Cobar	Not in study area
Willow Bend	Condobolin	Minor stand-alone surface water supply system
Cooks Gap	Cooks Gap	Not in study area
Coolah	Coolah	Not in study area
Cootamundra	Cootamundra	Not in study area
Noonbinna	Cowra	Minor surface water supply system
Wirrimah	Cowra	Minor surface water supply system
Darby's Falls	Darby's Falls	Minor surface water supply system
Dubbo	Dubbo	Not in study area
Elong Elong	Elong Elong	Rainwater fed supply
Euabalong	Euabalong	Not in study area
Euchareena	Euchareena	Minor surface water supply system
Fifield	Fifield	Rainwater fed supply
Cullen Bullen	Fish River	Fish River Water Supply (excl. Oberon) not modelled
Glen Davis	Fish River	Fish River Water Supply (excl. Oberon) not modelled
Marrangaroo	Fish River	Fish River Water Supply (excl. Oberon) not modelled
Portland	Fish River	Fish River Water Supply (excl. Oberon) not modelled
Wallerawang	Fish River	Fish River Water Supply (excl. Oberon) not modelled
Lidsdale	Fish River	Fish River Water Supply (excl. Oberon) not modelled
Rydal	Fish River	Fish River Water Supply (excl. Oberon) not modelled
Daroobalgie	Forbes Shire Villages	Rainwater fed supply
Garema	Forbes Shire Villages	Rainwater fed supply
Wirrinya	Forbes Shire Villages	Rainwater fed supply
Forest Reefs	Forest Reefs	Rainwater fed supply
Goolma	Goolma	Not in study area
Goulburn	Goulburn	Not in study area
Gulgong	Gulgong	Not in study area
Gundagai	Gundagai	Not in study area

DEMAND NODE	LOCAL WATER UTILITY	EXPLANATION
Hargraves	Hargraves	Not in study area
Hartley	Hartley	Minor stand-alone surface water supply system
Hill End	Hill End	Minor groundwater supply system
Hillston	Hillston	Not in study area
Hillview Estate	Hillview Estate	Minor groundwater supply system
Jenolan Caves Village	Jenolan	Minor stand-alone surface water supply system
Kingsvale	Jugiong	Minor stand-alone surface water supply system
Lake Burr. S+R Centre	Lake Burrendong	Minor stand-alone surface water supply system
Lue	Lue	Not in study area
Mandagery	Mandagery	Rainwater fed supply
Monteagle	Monteagle	Rainwater fed supply
Coolamon	Mt Arthur	Not in study area
Mudgee	Mudgee	Not in study area
Delgany Estate	Mullion Creek	Minor groundwater supply system
Mullion Creek	Mullion Creek	Minor groundwater supply system
Mumbil	Mumbil	Minor groundwater supply system
Murringo	Murringo	Rainwater fed supply
Muswellbrook	Muswellbrook	Not in study area
Narromine	Narromine	Not in study area
Nashdale	Nashdale	Not in study area
Neville	Neville	Rainwater fed supply
Newbridge	Newbridge	Rainwater fed supply
Ootha	Ootha	Minor surface water supply system
Junee	Oura	Not in study area
Temora	Oura	Not in study area
Ungarie	Oura	Not in study area
West Wyalong	Oura	Not in study area
Oura	Oura	Not in study area
East Parkes	Parkes	Too small for consideration
Nashes	Parkes	Too small for consideration
Pyramul	Pyramul	Not in study area
Quandialla	Quandialla	CTW supply from a local groundwater source
Rankins Springs	Rankins Springs	Not in study area
Wagga Wagga	Riverina Water	Not in study area
Charbon	Rylstone	Not in study area
Clandulla	Rylstone	Not in study area
Kandos	Rylstone	Not in study area
Rylstone	Rylstone	Not in study area
Scone	Scone/Aberdeen	Not in study area
Sofala	Sofala	Rainwater fed supply

DEMAND NODE	LOCAL WATER UTILITY	EXPLANATION
Lucknow	Spring Hill / Lucknow	Too small for consideration
Spring Hill	Spring Hill / Lucknow	Not in study area
Stuart Town	Stuart Town	Rainwater fed supply
Sunny Corner	Sunny Corner	Rainwater fed supply
Tarana	Tarana	Fish River Water Supply (excl. Oberon) not modelled
Warroo	Warroo	Minor stand-alone surface water supply system
Wattle Flat	Wattle Flat	Rainwater fed supply
Windeyer	Windeyer	Rainwater fed supply
Wollar	Wollar	Rainwater fed supply
Wyangala	Wyangala	Minor surface water supply system
Binalong	Yass District	Not in study area
Bowning	Yass District	Not in study area
Yass	Yass District	Not in study area

B.4 DEMAND-SIDE MANAGEMENT – DECISION SUPPORT SYSTEM

B.4.1 DATA SELECTION

The future demands of the demand nodes identified for modelling were forecasted using the following parameters:

- Climate data (SILO) (rainfall, evaporation and temperature)[4];
- Historical water production and consumption records (LWU/DWE);
- Historical Population (ABS) and WRI C population growth forecasts (WRI 2008);
- Historical Account (LWU) and Household size information (ABS); and
- Historical trends in the uptake of water efficient fixtures, appliances and fittings (ABS, AGO).

Within the residential and commercial customer categories, the breakdown of water consumption for different uses within the site was based on the results of the following studies:

- American Water Works Association Research Foundation, 2000, Residential End Uses of Water; and
- 2004 Residential End Use Measurement Study, 2005, Yarra Valley Water.

[4]SILO: Climate data sets created by the Bureau of Meteorology

LWU: Data supplied by the Local Water Utility,

DWE: Data contained within DWE LWU Performance Reports

ABS: Data obtained from the Australian Bureau of Statistics

WRI: Western Research Institute CENTROC Population Projections(11 December 2008)

AGO: Australian Greenhouse Office

B.4.2 TIME SERIES ANALYSIS

Water demand forecasts are generally prepared for "climate-normalised" or "average" climate conditions. The influence of climate on historical demands has the potential to distort trends in demands and bias the estimates of the starting point for projections. By way of example, if the recent historical record has been hotter and drier than the average, then it may create the impression of an upward trend in demand and result in a starting point for demand forecasts that is higher than the climate-normalised demand. Conversely if the recent records has been cooler and wetter than the average, the impression of a downward trend in demand is generated, resulting in a starting point for projections that is lower than the climate-normalised demand.

Where detailed information on either daily or monthly bulk water production was available, a regression analysis of the influence of climate on historical demands was undertaken. The analysis approach used is outlined in DWE 2003. Where this information was not available, annual demand trends were examined to determine an appropriate starting point for projections. The table below summarises the information available for each demand centre.

Where water restrictions were in place for part of the historical record, the climate-normalised demand was taken to be the demand in periods where water restrictions were not in place.

Examples of the time series analysis results where shown in Figures B-1 and B-2.

Table B-5: Demand Analysis Summary

DEMAND NODE	AVAILABLE DATA	ANALYSIS USED	MODEL R^2
Bathurst	Daily	Daily Regression	0.72
Central Tablelands Water	Monthly	Monthly Regression	0.94
Boorowa	Annual	Historical Average	N/A
Condobolin	Daily	Daily Regression	0.75
Cowra – Koorawatha	Daily	Daily Regression	0.54
Crookwell	Monthly	Monthly Regression	0.93
Cumnock – Yeoval	Monthly	Monthly Regression	0.75
Forbes	Monthly	Monthly Regression	0.97
Lake Cargelligo	Annual	Historical Average	N/A
Lithgow – Portland	Monthly	Monthly Regression	0.79
Molong	Annual	Historical Average	N/A
Murrumburrah (Harden)	Annual	Historical Average	N/A
Oberon	Monthly	None – demand record heavily restricted.	N/A
Orange	Daily	Daily Regression	0.63
Parkes – Peak Hill	Monthly	Monthly Regression	0.88
Wellington – Geurie	Daily	Daily Regression	0.72
Young	Annual	Historical Average	N/A

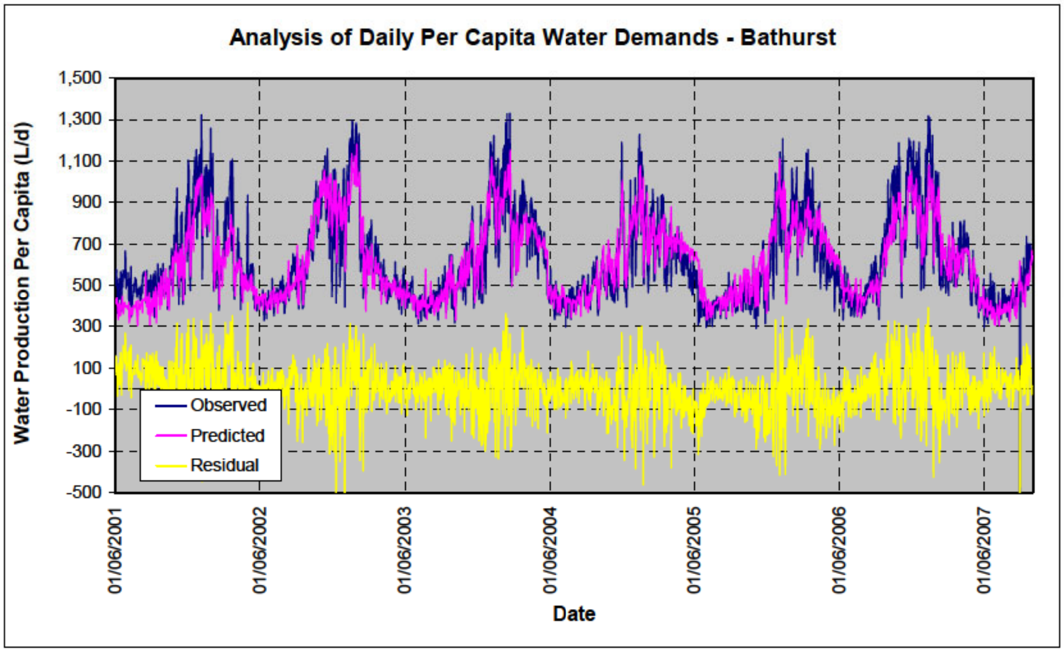

Figure B-1: Analysis of Daily Per Capita Water Demands - Bathurst

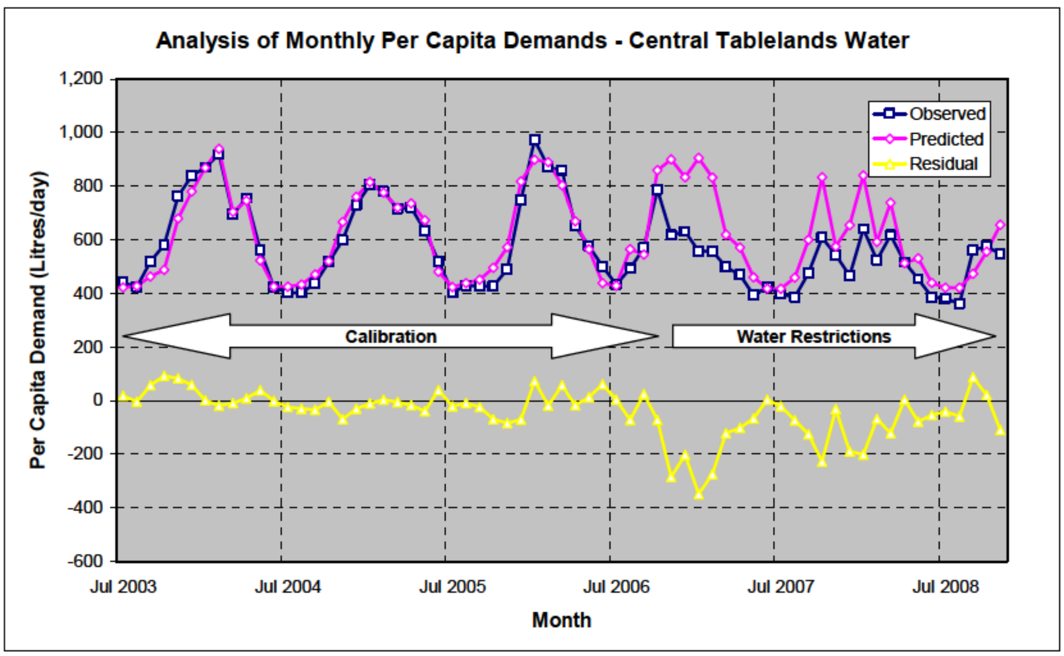

Figure B-2: Time Series Analysis of Monthly Per Capita Water Production - Central Tablelands Water

B.4.3 APPROACH

Due to inconsistent availability of data for the different towns across the CENTROC region, it was not possible to adopt one only approach that would be appropriate to prepare the demand forecast throughout the entire study area. Therefore, based on the information available in each case, a different approach was chosen among the three described below.

1. Where adequate bulk production and consumption data was available, a water tracking model was prepared to determine the actual and climate corrected production, consumption (by customer category) and losses contains more information on the models used and the climate correction process).
2. Where adequate bulk production data, but only limited consumption data was available, estimates of consumption and losses were made. The breakdowns in consumption by customer category (e.g. residential, commercial etc) were estimated based on the information supplied to DWE in support of the program of conversion of town water licences to volumetric entitlements in 2000 (under the Water Act, 2000).
3. Where bulk production or consumption data was unavailable or contained significant errors, bulk production records from the DWE LWU Performance Reports were used. The breakdowns in consumption by customer category (e.g. residential, commercial etc) were estimated based on the information supplied to DWE in support of the program of conversion of town water licences to volumetric entitlements in 2000 (under the Water Act, 2000).

Some smaller centres were not covered in the LWU Performance Reports or the Volumetric Study. In these cases, the consumption rates and customer category breakdowns in nearby areas were applied.

B.4.4 ASSUMPTIONS – DEMAND MANAGEMENT IMPACTS

In the development of forecasts of future demand management impacts, a number of assumptions are required regarding the assumed uptake of the option and the water savings. These assumptions are set out in Table B-6 below.

Table B-6: Demand Management Options

OPTIONS		ASSUMED MARKET PENETRATIONS	ASSUMED WATER SAVINGS
1	Residential Retrofit	27% of households in initial years of program. Relapse rate driven by return to baseline market for fixtures and appliances. 1.5% per annum households per year participate in maintenance program.	Showers – water efficient showers reduce water use by approximately 40% The use of flow regulated taps reduces water use by 10%
2	WELS	Increase in the market share of top loading washing machines by 10%.	36% reduction in water use in top loading machines.
3	Permanent Low Level Restrictions (Outdoor)	50% of customers comply with restrictions.	5% reduction in outdoor water use for participating customers.
4	BASIX	Baseline assumptions – number of households with water efficient fixtures are: • Showers: 27% • Taps: 25% • Toilets: 60% Increases to 80% under BASIX regulations. Relapse rate driven by return to baseline market for fixtures and appliances. 100% of new dwellings install rainwater tanks.	40% reduction in shower usage 10% reduction in tap usage ~50% reduction in toilet usage
5	Education – Water Conservation	50% of customers recognise and response to programs.	2% reduction in residential external use 1% reduction in commercial external use
6	Non-Residential Audit	10% of non-residential customers participate. High water using customers participate in program – typically use 4 times the amount of water of the average customer. 25% of customers relapse after 10 years.	20% reduction in water use for participating customers.

OPTIONS		ASSUMED MARKET PENETRATIONS	ASSUMED WATER SAVINGS
7	System Water Loss Management	25% of system covered each year	75% of avoidable losses eliminated in first year after targetting, 50% in second year and 25% in third year. No savings in fourth year until system re-visited.
8	25:75 Fixed to Variable Charge Ratio	All customers in all customer categories covered.	Based on price elasticity of: • -0.05 for internal use; • -0.20 for external use.

B.5 PURRS MODEL

PURRS stands for Probabilistic Urban Rainwater and Wastewater Reuse Simulator.

B.5.1 DATA SELECTION

Selection of Rainfall and Temperature Records

Reliable analysis of water use and the performance of rainwater tanks depends on the use of realistic water demands and local rainfall sequences. The physical processes involved in rainwater harvesting, including collection of roof runoff in tanks and rainwater supply to households, is most accurately modelled by using sub-daily time steps and the longest available rainfall records.

Daily rainfall and temperature records were obtained from the Bureau of Meteorology (BoM) containing greater than 10 years of data including the current drought, for locations throughout the CENTROC region (Table B- 7 and Table B- 8). In addition, pluviograph (6 minute) rainfall records containing greater than 10 years of data were obtained from the Bureau of Meteorology (Table B-9). A total of 72 daily rainfall and 13 pluviograph records were identified and some of these records were used to derive long synthetic pluviograph records at each location.

Table B- 7: Daily Rainfall Records from BOM used in the Study

LOCATION	BOM STATION	START	FINISH	LENGTH (YEARS)	AVERAGE ANNUAL RAINFALL (MM)
Bathurst	63004	1/1/1868	31/12/2007	140	631
Blayney – Carcoar	63010	1/1/1882	31/12/2007	125	777
Boorowa	70301	1/1/1883	31/12/1907	25	552
Canowindra	65006	1/1/1887	31/12/2007	121	598
Condobolin	50059	1/1/1882	31/12/2007	126	427
Cowra – Koorawatha	63021	1/1/1890	31/12/2007	118	613
Crookwell	70025	1/1/1884	31/12/2007	124	856
Cudal – Cargo – Manildra	65010	1/1/1885	31/12/2007	123	635
Cumnock – Yeoval	65011	1/1/1887	31/12/2007	121	647
Forbes	65016	1/1/1892	31/12/2007	115	524
Gooloogong- Eugowra	65019	1/1/1890	31/12/2007	118	597
Grenfell	73014	1/1/1896	31/12/2007	122	624
Lake Cargelligo	75039	1/1/1884	31/12/2007	124	423
Lithgow – Portland	63224	1/1/1888	31/12/2007	120	832
Molong	65023	1/1/1885	31/12/2007	123	703
Murrumburrah – Harden	73029	1/1/1889	31/12/2007	123	612
Oberon	63063	1/1/1889	31/12/2007	119	856
Orange	63065	1/1/1871	31/12/2007	137	832
Parkes	65024	1/1/1885	31/12/2007	123	571
Wellington – Geurie	65034	1/1/1882	31/12/2007	126	571
Young	73056	1/1/1876	31/12/2007	132	654

Table B- 8: Daily Temperature Records from BOM used in the Study

LOCATION	BOM STATION	START	FINISH	LENGTH (YEARS)	AVERAGE DAILY TEMPERATURE (°C)
Bathurst	63004	1/1/1871	31/12/2007	137	19.8
Blayney - Carcoar	63010	1/1/1965	31/12/1975	11	18.3
Boorowa	70220	1/1/1947	31/12/1969	23	20.7
Canowindra	65006	1/1/1965	31/01/1982	18	24.8
Condobolin	50014	1/12/1965	31/12/2007	43	24.8
Cowra - Koorawatha	63021	1/1/1957	31/12/2007	51	23.5
Crookwell	70025	1/1/1965	31/12/1975	11	18.2
Cudal – Cargo - Manildra	63065	1/1/1951	31/7/1975	25	19.7
Cumnock - Yeoval	65065	1/1/1957	31/7/1975	19	23.2
Forbes	65016	1/4/1873	30/04/2007	135	23.8
Gooloogong- Eugowra	65006	1/1/1907	31/12/2007	101	24.8
Grenfell	73014	1/1/1965	30/04/2007	43	22.5
Lake Cargelligo	75039	1/1/1965	30/04/2007	43	25.1
Lithgow - Portland	63224	1/8/1965	30/04/2007	43	18.2
Molong	65023	1/1/1957	31/7/1975	19	22.3
Murrumburrah - Harden	73029	1/9/1967	31/3/1980	14	21.8
Oberon	63063	1/1/1965	30/4/2007	43	16.9
Orange	63065	1/1/1951	31/7/1975	25	19.7
Parkes	65024	1/10/1997	30/4/2007	10	23.4
Wellington - Geurie	65034	1/1/1965	28/2/2005	40	24.4
Young	73056	1/1/1965	31/10/1991	27	22.3

Table B-9: Pluviograph Records from the BOM used in the Study

LOCATION	BOM STATION	START	FINISH	LENGTH (YEARS)
Blowering Dam	72056	1/3/1955	31/12/1973	18
Burrinjuck Dam	73007	1/5/1911	31/8/2005	70
Canberra Airport	70014	1/12/1921	31/12/2007	63
Condobolin Soil Conservation	50102	1/7/1957	31/12/1974	17
Coonabarabran	64046	1/7/1971	30/6/2006	26
Cowra Research Centre	63023	1/10/1941	30/04/2006	57
Crookwell Post Office	70025	1/2/1956	31/10/1974	18
Deniliquin Memorial	74039	1/7/1950	30/11/1977	26
Hume reservoir	72023	1/3/1955	31/3/2006	49
Moree	53048	1/4/1964	30/6/1995	31
Oberon Dam	63108	1/1/1955	31/3/1988	28
Orange Agricultural Institute	63254	1/5/1984	30/6/2006	22
Rylestone	62026	1/9/1955	31/12/1973	18
Wagga Wagga Research Centre	74114	1/9/1946	31/1/2004	49
Wellington Research Centre	65035	1/02/1961	31/2/2005	44

B.5.2 DEVELOPMENT OF LONG TERM PLUVIOGRAPH RAINFALL RECORDS

Synthetic pluviograph (6 minute) rainfall records were derived at locations with long daily rainfall records using a non-parametric nearest neighbourhood scheme developed by Coombes[5]. At a given site with a daily rainfall record, data from pluviograph rainfall records with different time periods in surrounding areas can be utilised to disaggregate daily rainfall into a synthetic pluviograph rainfall record. A diagram of the concept is shown in Figure B-3.

[5] Coombes P.J., 2004. Development of Synthetic Pluviograph Rainfall Using a Non-parametric Nearest Neighbourhood Scheme. WSUD2004 conference. Adelaide.

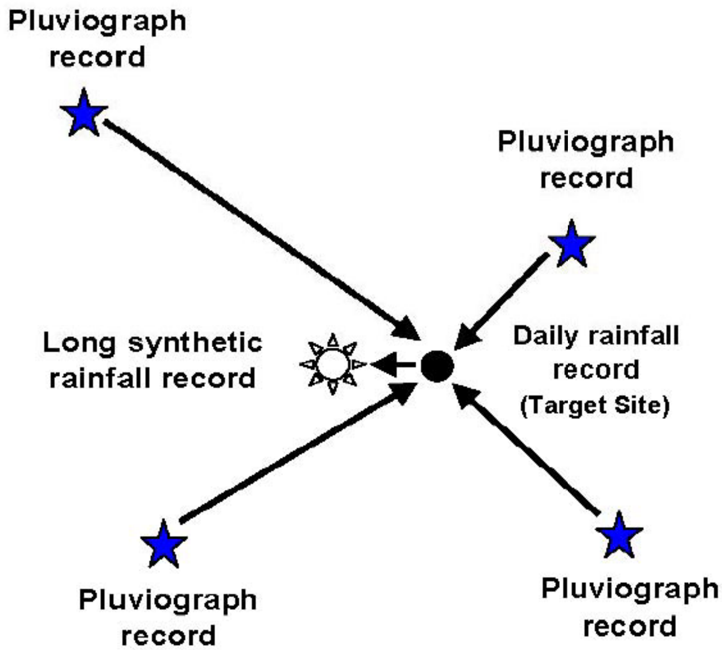

Figure B-3: Diagram of the non-parametric nearest neighbourhood scheme for development of synthetic pluviograph records

The non-parametric scheme utilises climate and seasonal parameters (daily rainfall depth, month, count of days since last rain event) at the daily rainfall and nearby pluviograph rainfall sites to select a day of pluviograph rainfall from the most appropriate nearby pluviograph record. For each day in the daily rainfall record a day of pluviograph rainfall record is chosen using climate and seasonal parameters, and a ranking scheme. The nearby pluviograph records can be ranked on the basis of proximity to the location of the daily rainfall record and similarity of annual rainfall depths, topography and distance from the coast. This allows disaggregation of the daily rainfall records into a series of storm events and dry periods that constitute a synthetic pluviograph rainfall record.

This process ensures that the synthetic continuous rainfall record will have similar rainfall patterns to the chosen site whilst the total daily rainfall depths in the synthetic rainfall record are conditioned on the daily rainfall record. In the non-parametric nearest neighbourhood scheme a rank is used to prioritise the search process for a continuous rainfall pattern that best matches the climate characteristics of the daily rainfall record on any given day.

Example from the Orange Region

A synthetic pluviograph rainfall record with a length of 137 years and average annual rainfall depth of 832 mm was constructed for the Orange region using daily rainfall from Orange and pluviograph rainfall from Orange, Wellington, Oberon and Rylestone.

B.5.3 APPROACH

A schematic of the basic processes in the PURRS (Probabilistic Urban Rainwater and Wastewater Reuse Simulator) model is shown in Figure B-4. The rainfall input to the model can be from pluviograph rainfall data, the DRIP (Disaggregated Rectangular Intensity Pulse) event rainfall model developed or the synthetic pluviograph rainfall generator. The synthetic pluviograph rainfall generator can be used to create a rainfall pluviograph record from daily rainfall at locations where incomplete or no pluviograph data is available. A more complete description of the PURRS model is provided by Coombes[6].

[6] Coombes P.J., 2006. Integrated Water Cycle Modeling Using PURRS (Probabilistic Urban Rainwater and wastewater Reuse Simulator). Urban Water Cycle Solutions.

The rainfall falling on roof areas discharges to a first flush device and if the capacity of the roof gutter system is exceeded, rainfall also overflows from the roof gutter system to impervious areas as shown in Figure B-5. Rainwater is then routed through the first flush device to a rainwater tank. Water is drawn from the rainwater tank for household uses (such as laundry, toilet and outdoor uses) and, if the water level in the rainwater tank is below a set minimum level, the tank is topped up with mains water at a nominated rate or mains water is used to supply all household uses. Mains water is used to supply all household uses not sourced from the rainwater tank and to supplement the rainwater tank supply. The rainwater tank overflows can be directed to an infiltration trench, an on-site detention tank, a stormwater tank or the street drainage system.

Rain falling on impervious areas can be directed to pervious areas, an on-site detention tank or the street drainage system. Rain falling on pervious areas can infiltrate to the soil and can discharge to the atmosphere via evapotranspiration, an on-site detention tank or the street drainage system.

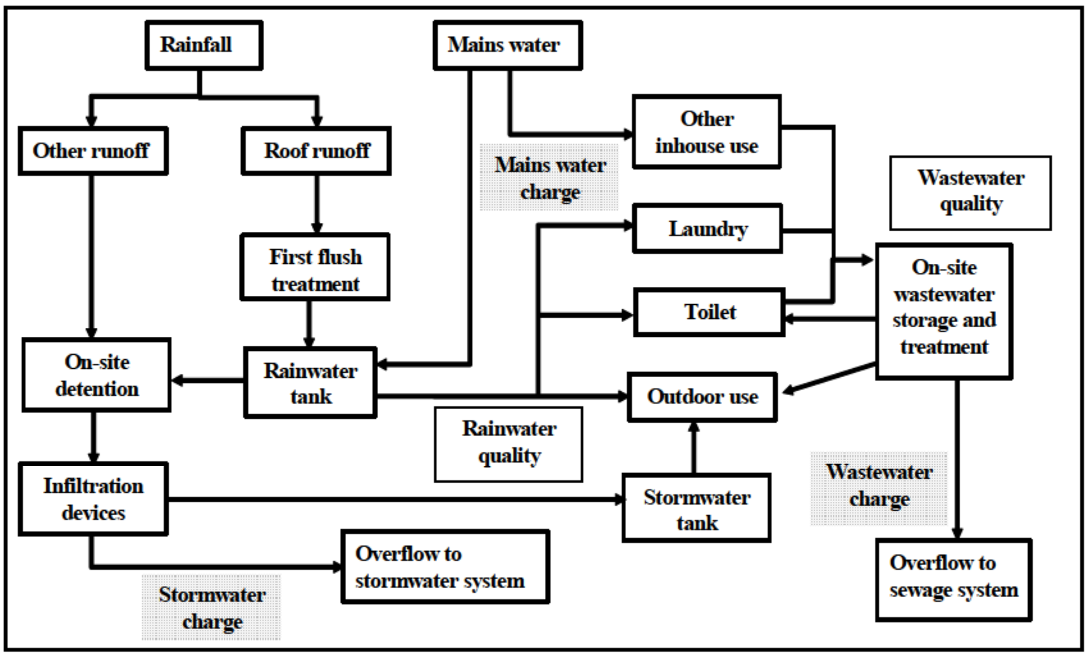

Figure B-4: Schematic of the Basic Processes in the PURRS Water Balance Model

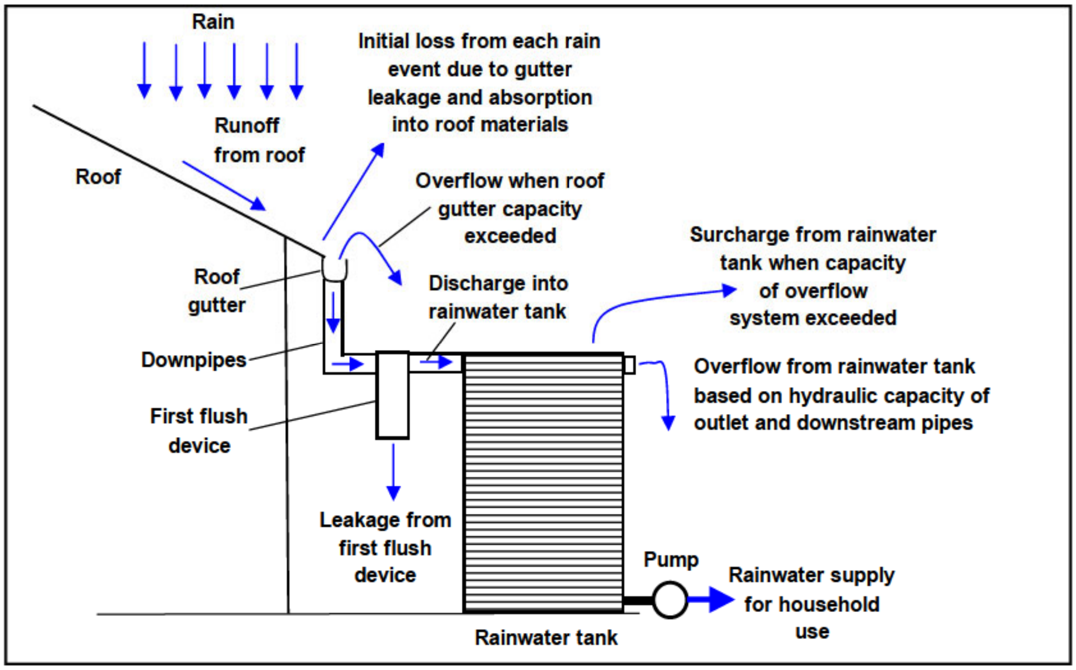

Figure B- 5: Schematic of the Roof Runoff to Rainwater Tank Processes in PURRS

An importance advance in the simulation of roof runoff process as shown in Figure B- has been included in the PURRS model. The roof runoff processes used in the model do not include arbitrary initial and continuing losses because, while these processes may be adequate for stormwater runoff from rural or urban catchments, they are not relevant to rainwater harvesting from roofs. Roof systems are relatively impervious and are not subject to significant evapotransporation or infiltration losses. More accurately, these systems are subject to losses that are based on leakage from roof gutter systems and overflows from roof gutter systems when the capacity of gutters and downpipes is exceeded.

Monitoring studies by the author has revealed that initial gutter losses range from 0 to 0.8 mm of roof runoff with the average initial gutter losses being about 0.5 mm[7]. This study has employed an initial gutter loss of 0.5 mm.

Diurnal Pattern of Indoor and Outdoor Water Use

In order to determine indoor and outdoor water use at short time steps in a water balance model a diurnal water use pattern is required. A diurnal water use pattern was adopted from previous studies into the performance of rainwater tanks for use in the PURRS Model. The assumed diurnal water use pattern for a household is shown in Figure B-6.

[7] Coombes P.J., (2002). Rainwater tanks revisited – new opportunities for urban water cycle management. PhD thesis. University of Newcastle. Australia.

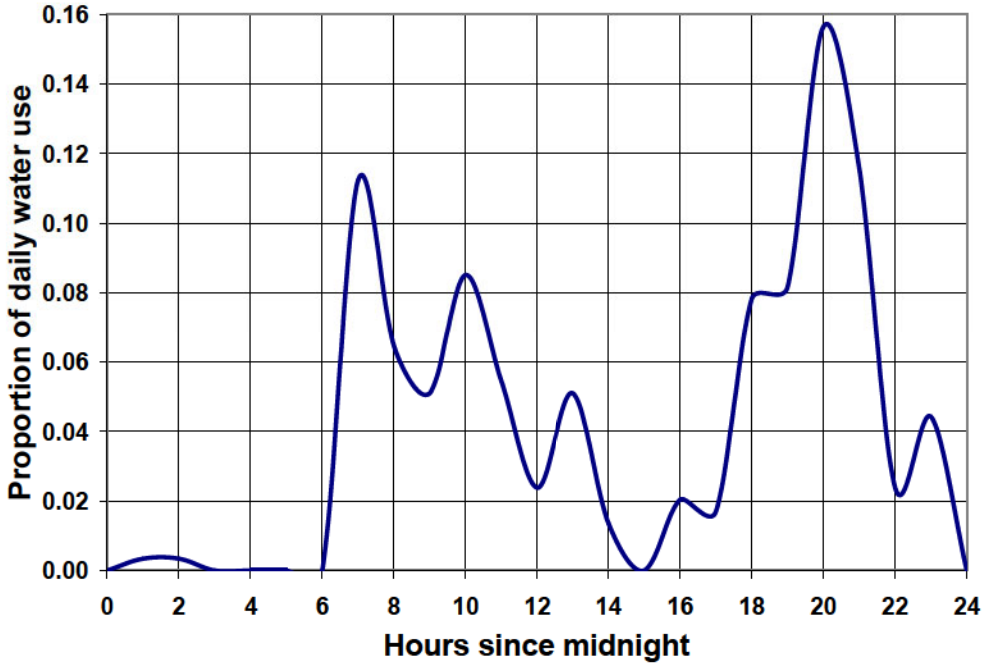

Figure B- 6: The Diurnal Water Use Pattern at a Household

The diurnal water use pattern shown in Figure B-6 have been transformed into a normalised water use (cumulative use/daily use) versus normalised time relationship (Figure B-7 to enable the PURRS model to determine diurnal indoor and outdoor water use patterns.

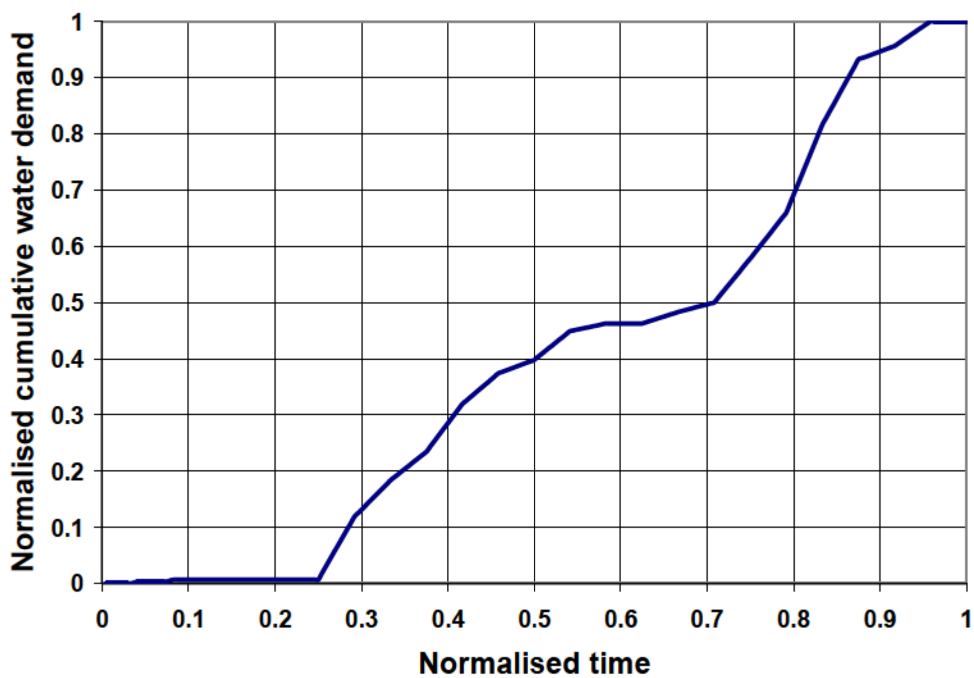

Figure B-7: Normalised Diurnal Water Use Pattern used in the PURRS Model

The PURRS model calculates water consumption at six-minute intervals using indoor and outdoor water use patterns established for a particular location, daily water demand algorithms and the normalised diurnal water use pattern shown in Figure B-7.

The Outdoor Water Use Model

Domestic outdoor water use such as garden watering, car washing and filling of swimming pools is seen to be a recreational pastime that is dependant on human behaviour. Outdoor water use behaviour is significantly modified by human reaction to daily temperature, days without rainfall and rainfall depth.

The probability of outdoor water use is expected to increase as the length of a period without rainfall increases and the volume of water used is a function of temperature and normal water use patterns. People are more likely to use water outside of the house when it is hot and dry, and in accordance with habits.

During a day with rainfall there is a smaller probability of water use and the volume of water used is dependent on the rainfall depth. There is a chance of outdoor water use when people perceive rainfall depth to be insignificant and, conversely, when rainfall depth is perceived to be large there will be no outdoor water use. When rainfall depth is sufficiently high, people may not use water outside of the house for a number of days. These behavioural considerations have been formalised into a probabilistic framework by Coombes[8] that drives the daily simulation of outdoor water use. This climatic behavioural simulation approach is used in the PURRS model.

Indoor Water End Uses

Simulation of daily indoor uses in the PURRS model are based on the values estimated using the DSS, the diurnal patterns provided in Figure B-7 and a distribution of household indoor water uses, including kitchen, laundry, toilet, bathroom and hot water uses. In this study the distribution of indoor water uses from the DSS that were modified for use in PURRS as shown in Figure B-8.

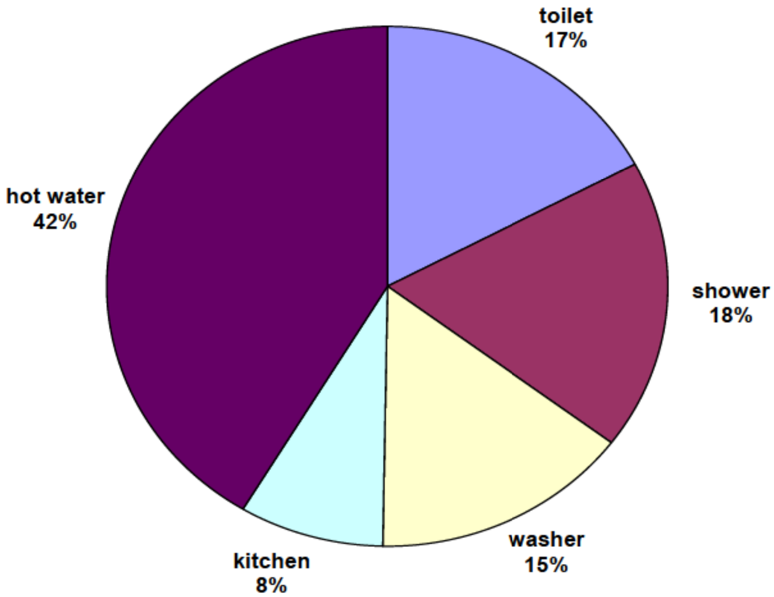

Figure B- 8: Distribution of Household Indoor Water Uses

Configuration of Rainwater Storages and Supply

Two different mains water back up processes to supplement rainwater supply from 5 kL rainwater tanks are evaluated in this study, employing either mains water top up or mains water bypass systems. The configuration of the rainwater tanks with mains water top up systems used in this study is shown in Figure B-9.

[8] Coombes P. J., G. Kuczera and J.D. Kalma, 2000. A behavioural model for prediction of exhouse water demand, 3rd International Hydrology and Water Resource Symposium, 793-798, Perth, Australia.

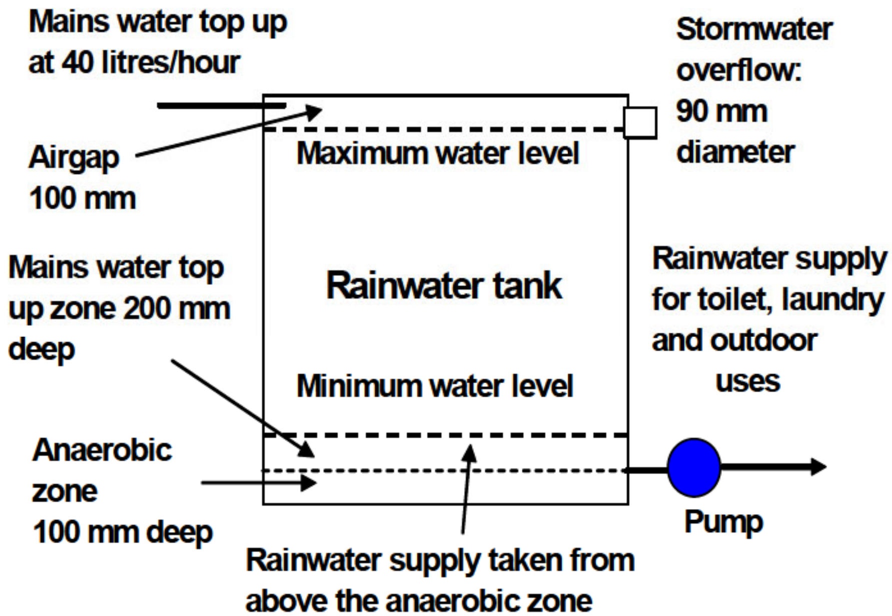

Figure B- 9 Configuration of a Rainwater Tank with Mains Water Trickle Top Up

Figure B-9 shows that rainwater stored in the tank is used to supply domestic toilet, laundry and outdoor water uses. Runoff from roof surfaces passes through a first flush device with a capacity of 20 litres and into the rainwater tank. Whenever water levels in the rainwater tanks are drawn below a depth of 300 mm, the tanks were topped up with mains water at a rate of 40 litres/hour. In the mains water bypass scenario, mains water is supplied to households for toilet, laundry and outdoor uses when water levels in rainwater tanks reach a depth of 300 mm.

An important consideration in the analysis of household water use behaviour and the rainwater use is the behaviour modification created by rainwater tanks. Rural users of rainwater tanks employ a form of household water rationing that is based on storage levels in their rainwater tanks and climate factors. This process has some similarity to regional water restriction policies used to manage the security of a city's water supply.

B.5.4 ASSUMPTIONS

Distribution of Household Sizes

The use of average water demands and average household sizes to simulate water use and the performance of rainwater harvesting strategies produces significant error.[9] The performance of domestic rainwater harvesting systems or, indeed, any other decentralised water management strategy is primarily dependent on water use behaviour in each household. Water use behaviour is also varies with household size and dwelling type.

Average water demands at any location depend on the distribution of household sizes and dwelling types. The distribution of household sizes does not take the form of a normal distribution and is skewed toward smaller households. As a consequence of the skewed distribution of household sizes, average water demands for a certain area cannot represent the water demands of an average household. The distributions of household sizes used in this study were sourced from the Australian Bureau of Statistics and are shown in Table B-8.

[9] Coombes P.J., and M.E. Barry, 2006. The effect of time steps and average assumptions on the continuous simulation of rainwater harvesting strategies. Water Science and Technology. IWA Publishing. London.

Table B- 10: Distribution of Household Sizes Used in this Study

LOCATION	PROPORTION OF DWELLINGS (%) PER HOUSEHOLD SIZE (PEOPLE)				
	1	2	3	4	5
Bathurst	26	34	16	15	9
Blayney - Carcoar	25	35	14	14	12
Boorowa	36	36	11	9	9
Canowindra	29	40	11	11	9
Condobolin	28	37	12	11	12
Cowra - Koorawatha	27	38	13	12	10
Crookwell	30	36	12	17	8
Cudal – Cargo - Manildra	25	37	15	10	13
Cumnock - Yeoval	31	44	12	9	4
Forbes	31	34	14	11	9
Gooloogong- Eugowra	31	44	12	9	4
Grenfell	37	36	11	9	7
Lake Cargelligo	32	36	13	11	10
Lithgow - Portland	32	34	14	13	7
Molong	26	38	14	12	10
Murrumburrah - Harden	32	36	13	11	10
Oberon	31	31	13	14	11
Orange	28	34	15	14	9
Parkes	30	34	14	13	10
Wellington - Geurie	32	33	13	12	10
Young	31	34	14	11	9

Other Water Use

The relationships for non-residential water demands developed at the University of Newcastle[10,11], were modified for use in this study. Non residential water demand in each town including losses and unaccounted for use has been defined as Other water use. Other water use on each day was defined as: $Other = a + b(year - 2008)(1 + amp.\sin(mth + phase)/12)^{Indyr} - c.rain + d(temp - 21)drydays$

Where,

a and *b* are parameters defining growth in other water demand,

amp and *phase* describe the seasonal pattern for water use,

Indyr is an exponent used to define the magnitude of water use,

c is a parameter that utilises daily rainfall (rain) to alter water use,

[10] Coombes P.J., G. Kuczera, J. D. Kalma and J. R. Argue (2002). An evaluation of the benefits of source control measures at the regional scale. Urban Water. London.

[11] Kuczera G., and W.S. Ng (1994). Stochastic economic approach to headworks augmentation timing. Research Report 72. Urban Water Research of Australia.

d is a parameter used to define the impact of daily temperature (*temp*) and count of dry days (*drydays*) on daily water use.

This relationship for urban water demand was chosen because it includes climate variables that can account for the climate processes.

Performance of Rainwater Tanks

The household water use scenarios analysed in this study include rainwater harvesting from 5 kL rainwater tanks for laundry, toilet and outdoor uses for 80% of new and redeveloped housing. Rainwater runoff from roofs with areas of 200 m^2 is collected in the tanks and the average annual rainwater yields at each location are shown in Table B- 11.

Table B- 11: Rainwater Yields for Different Household Sizes at Each Location

LOCATION	RAINWATER YIELD (KL/YR) VERSUS HOUSEHOLD SIZE (PEOPLE)				
	1	2	3	4	5
Bathurst	67	75	80	84	87
Blayney - Carcoar	72.4	83.4	91.9	98.3	103.1
Boorowa	43.2	56.4	66.4	73.2	77.3
Canowindra	68.5	76	80.9	84.3	86.7
Condobolin	58.9	60.6	61.8	62.7	63.4
Cowra - Koorawatha	73.7	78.5	82	84.6	86.7
Crookwell	40.4	55.8	69.1	80.2	89.3
Cudal – Cargo - Manildra	66.5	76.6	83.4	87.7	90.7
Cumnock - Yeoval	72.3	78.1	82.2	85.4	88
Forbes	64	68.6	71.5	73.7	75.2
Gooloogong- Eugowra	66.5	73.9	78.8	82.2	84.8
Grenfell	65.9	74.1	79.8	83.8	86.8
Lake Cargelligo	61.5	62.9	63.9	64.7	65.4
Lithgow - Portland	65.7	75.9	83.9	89.9	94.5
Molong	79.1	85.6	90.2	93.7	96.4
Murrumburrah - Harden	67	73.4	78.4	82.1	84.9
Oberon	74	86.1	95.6	102.9	108.3
Orange	72.9	84.3	93.3	100.2	105.4
Parkes	67.6	71.6	74.4	76.2	77.7
Wellington - Geurie	71.5	74.6	76.9	78.6	80.1
Young	58.7	67.7	74.8	80.3	84.4

Table B- 11 shows that average annual rainwater yields range from 40 kL to 108 kL throughout the CENTROC region.

B.6 VERIFICATION OF WATER DEMANDS

The results from the demand simulations compiled for each location using PURRS were verified against the annual results from the DSS for the first replicate in the analysis to ensure consistency in the methods. These results from the verification process are presented in Figure B- 10 to Figure B-30. Note that the PURRS simulation of residential water demands includes the up take of rainwater tanks that can be expected due the BASIX legislation.

The figures show that the demand replicates generated using PURRS was able to successfully replicate the trends in water use estimated by the DSS whilst allowing climate generated responses in water using behaviour.

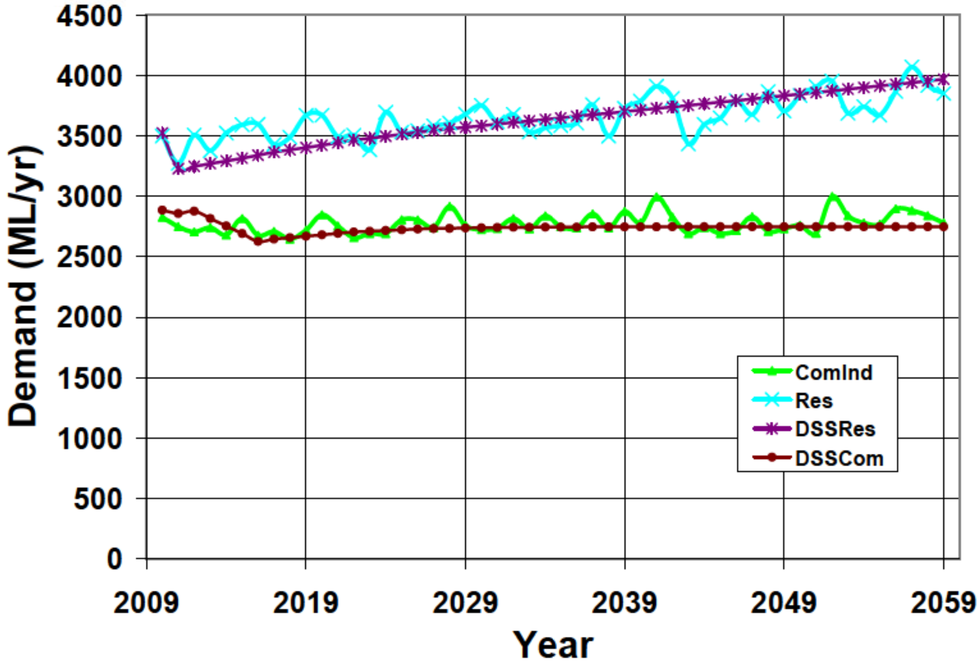

Figure B- 10: Verification of the Water Demands Generated by PURRS against the DSS Results for Bathurst

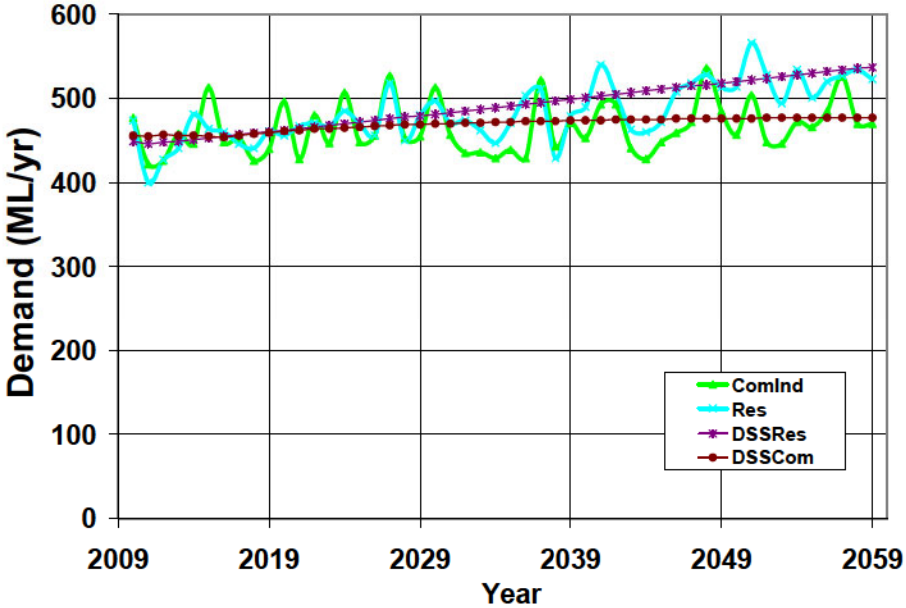

Figure B- 11: Verification of the Water Demands Generated by PURRS against the DSS results for Blayney

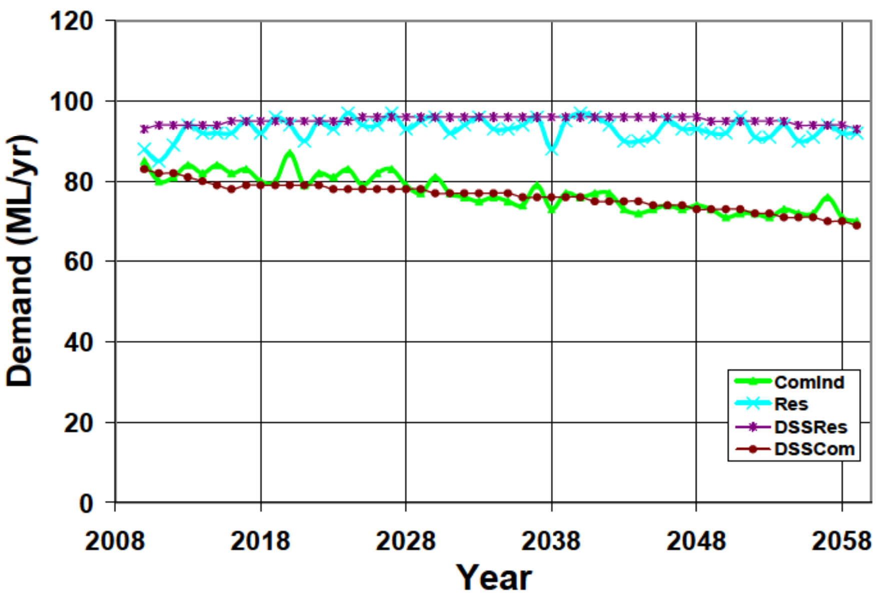

Figure B- 12: Verification of the Water Demands Generated by PURRS against the DSS results for Boorowa

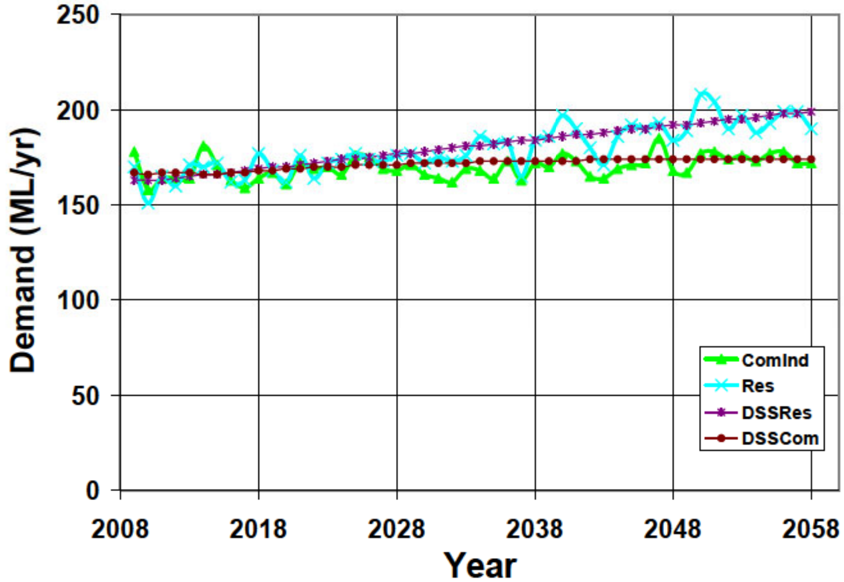

Figure B- 13: Verification of the water demands generated by PURRS against the DSS results for Canowindra

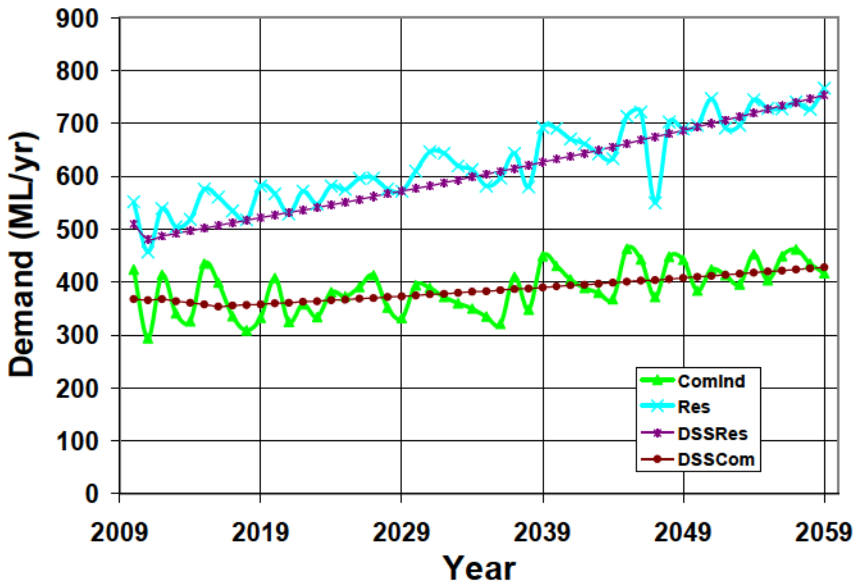

Figure B- 14: Verification of the Water Demands Generated by PURRS against the DSS results for Condobolin

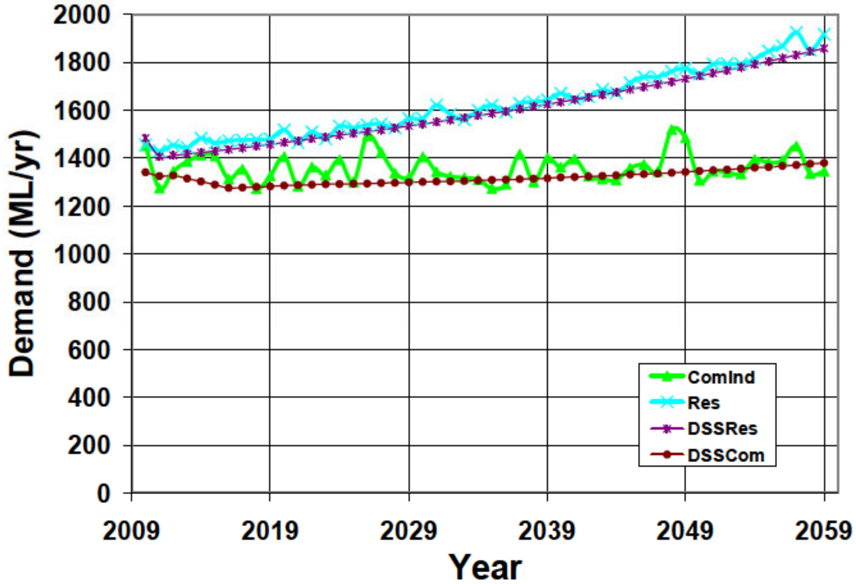

Figure B- 15: Verification of the Water Demands Generated by PURRS against the DSS results for Cowra

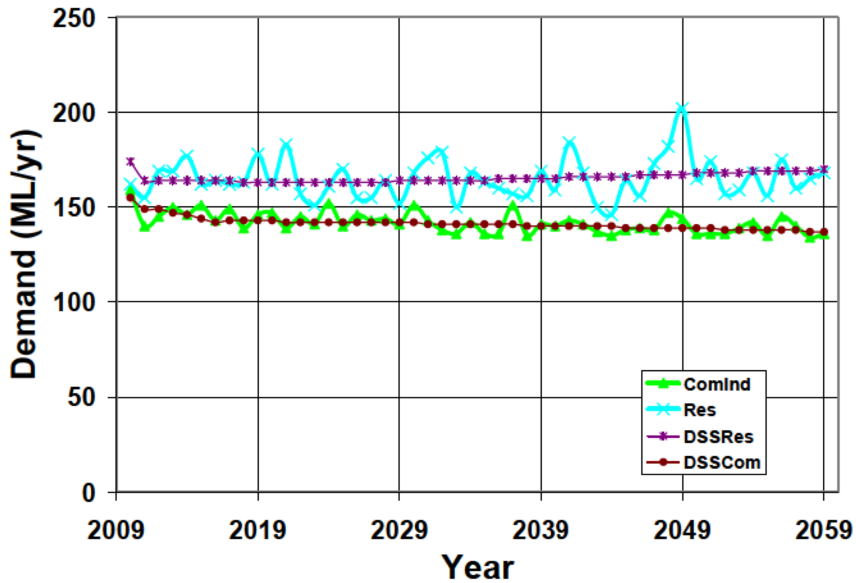

Figure B- 16: Verification of the Water Demands Generated by PURRS against the DSS results for Crookwell

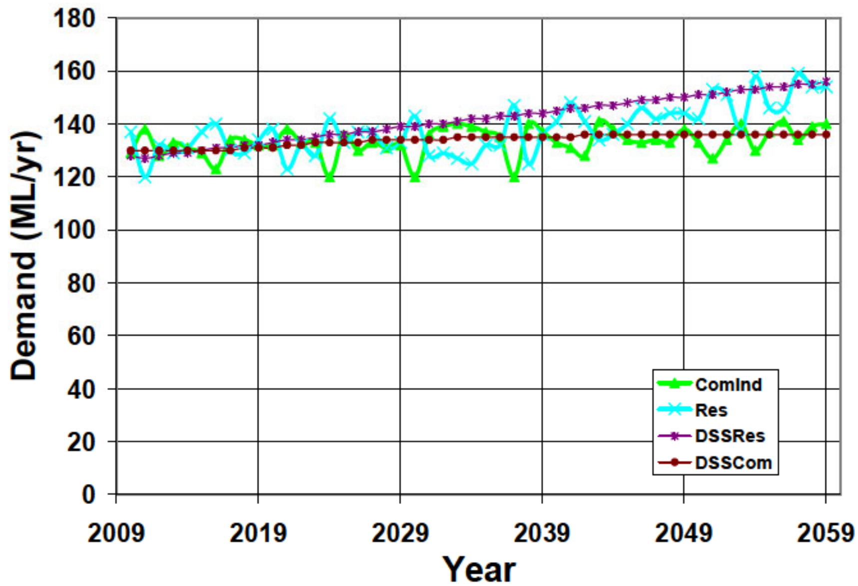

Figure B-17: Verification of the Water Demands Generated by PURRS against the DSS results for Cudal

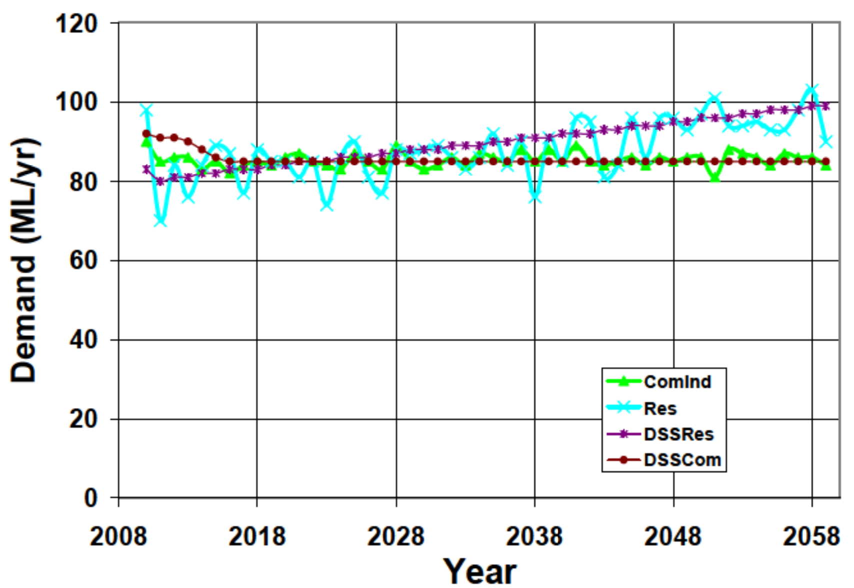

Figure B- 18: Verification of the Water Demands Generated by PURRS against the DSS results for Cumnock Yeoval

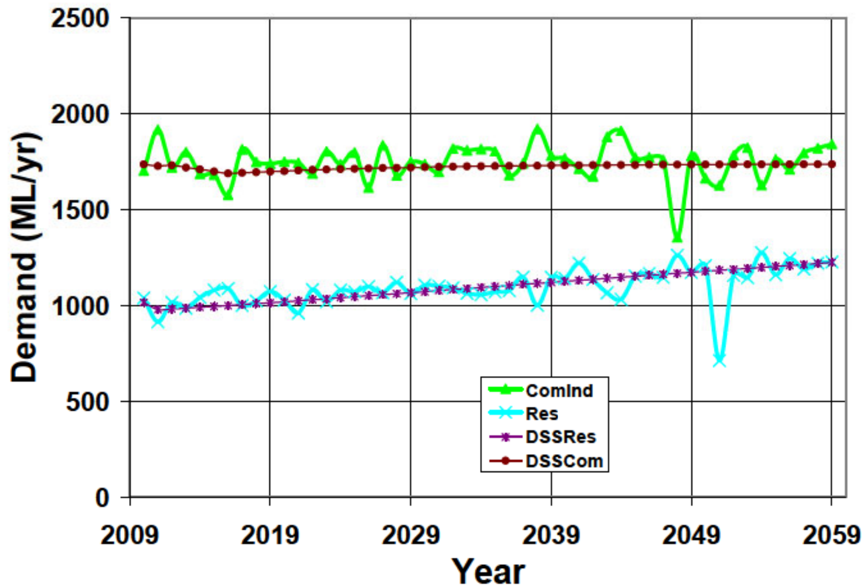

Figure B- 19: Verification of the Water Demands Generated by PURRS against the DSS results for Forbes

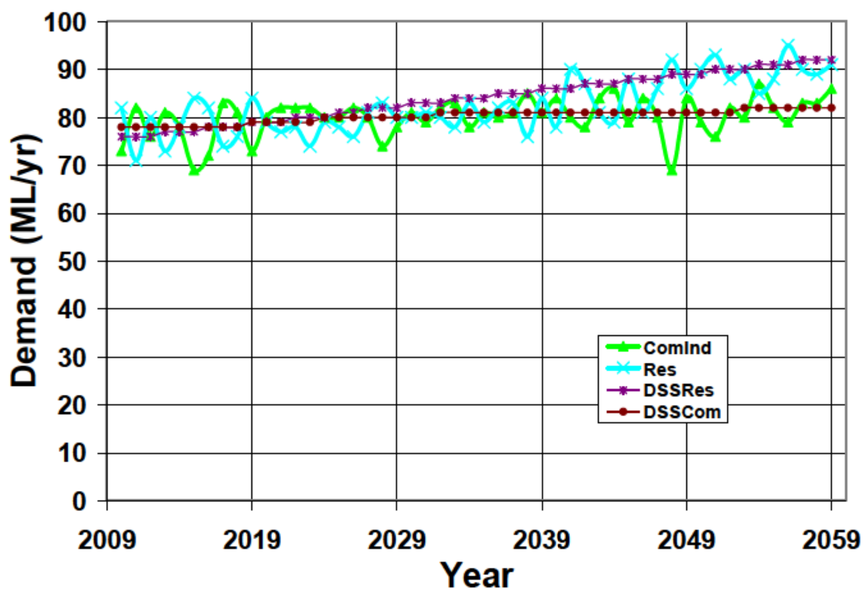

Figure B- 20: Verification of the Water Demands Generated by PURRS against the DSS results for Gooloogong

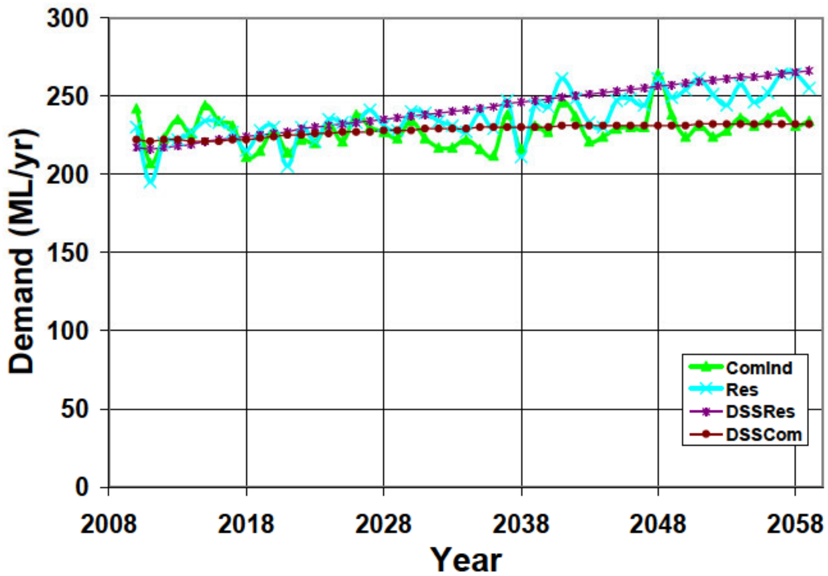

Figure B- 21: Verification of the Water Demands Generated by PURRS against the DSS results for Grenfell

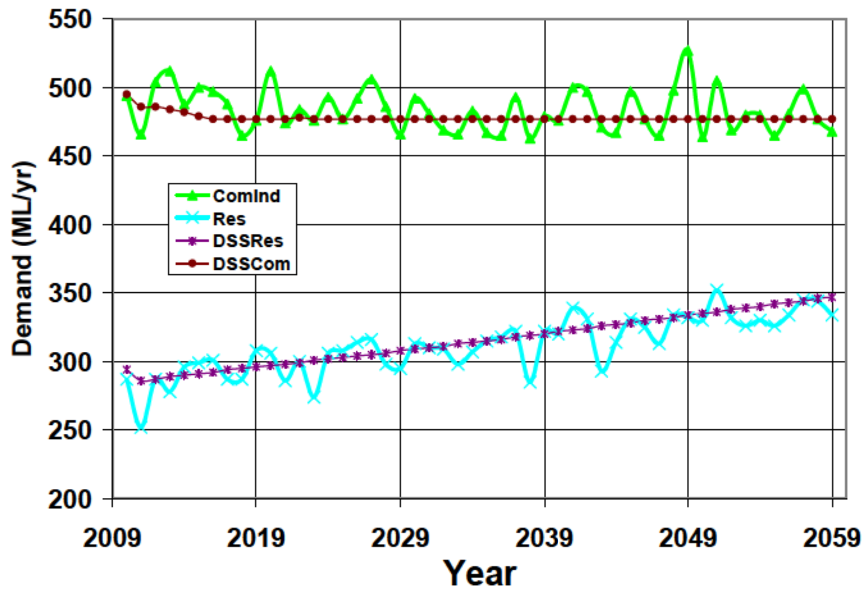

Figure B- 22: Verification of the Water Demands Generated by PURRS against the DSS results for Harden

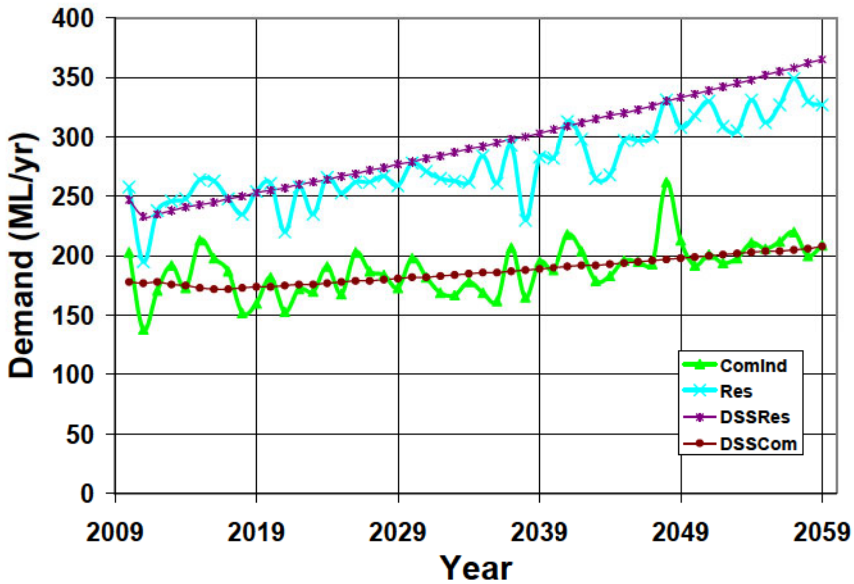

Figure B- 23: Verification of the Water Demands Generated by PURRS against the DSS results for Lake Cargelligo

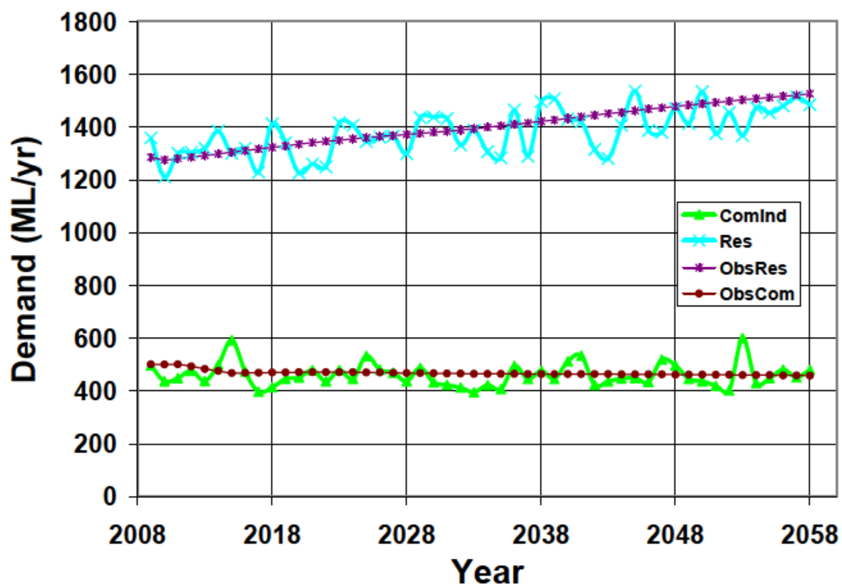

Figure B- 24: Verification of the Water Demands Generated by PURRS against the DSS results for Lithgow

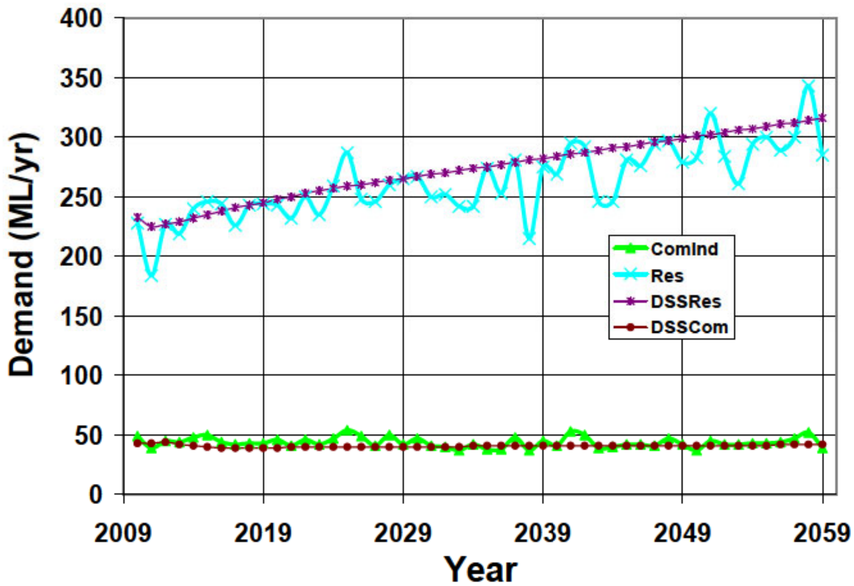

Figure B- 25: Verification of the Water Demands Generated by PURRS against the DSS results for Molong

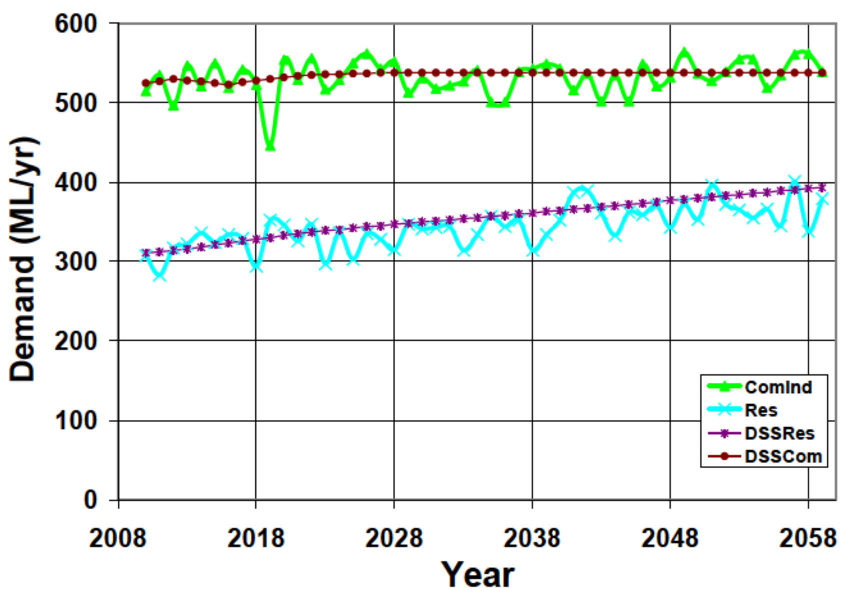

Figure B- 26: Verification of the Water Demands Generated by PURRS against the DSS results for Oberon

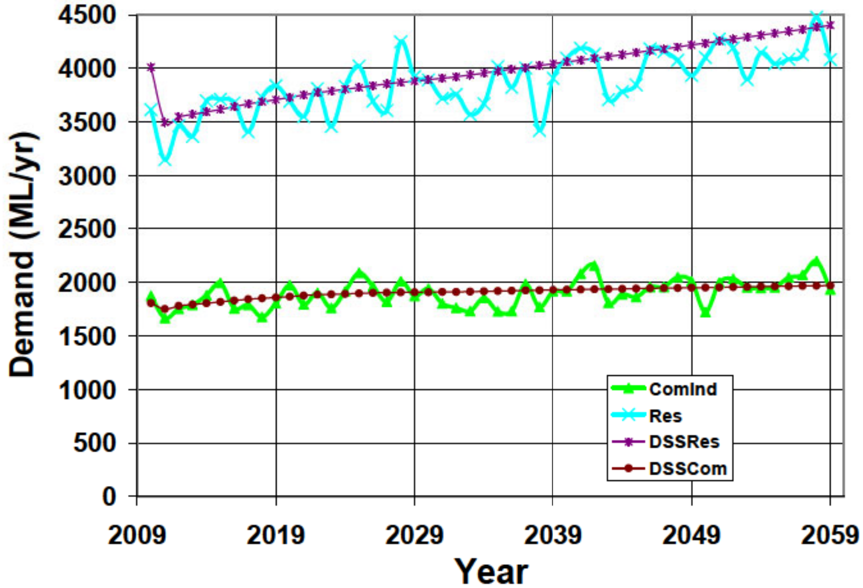

Figure B- 27: Verification of the Water Demands Generated by PURRS against the DSS results for Orange

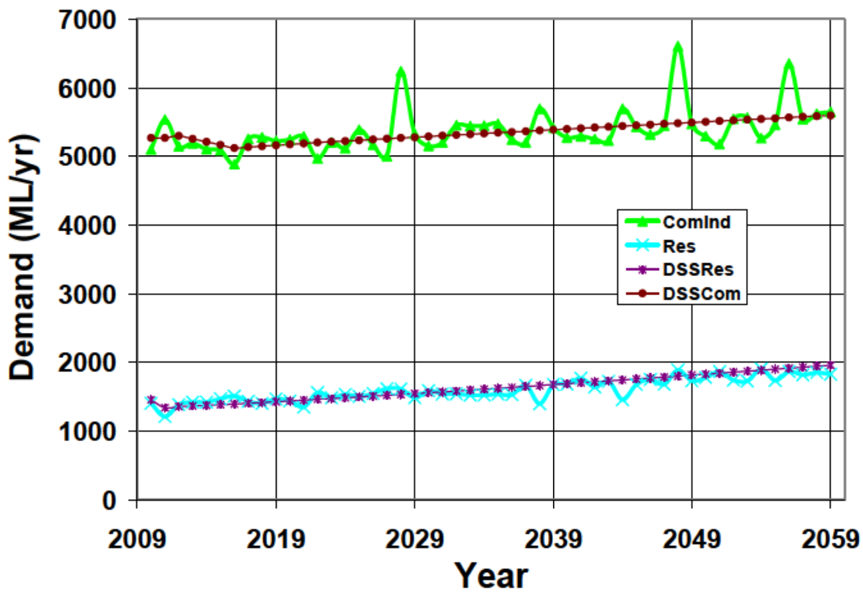

Figure B- 28: Verification of the Water Demands Generated by PURRS against the DSS results for Parkes

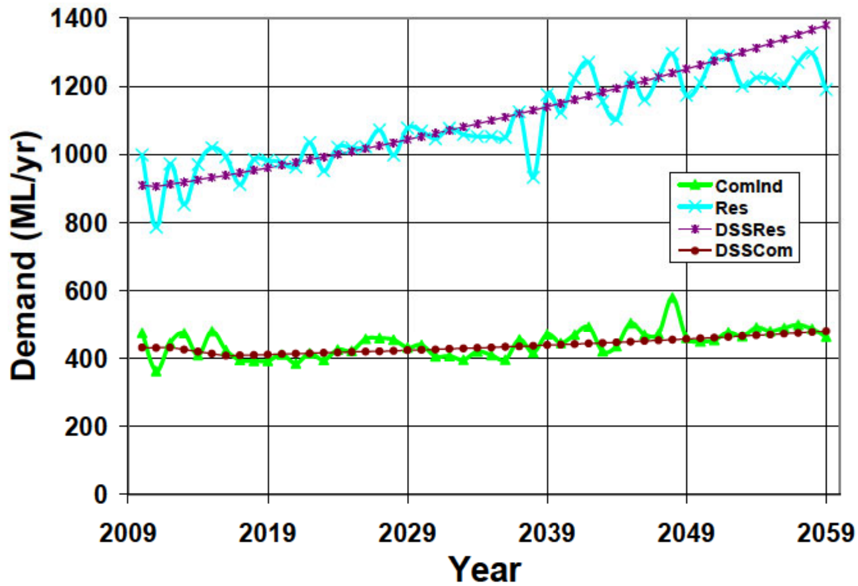

Figure B- 29: Verification of the Water Demands Generated by PURRS against the DSS results for Wellington

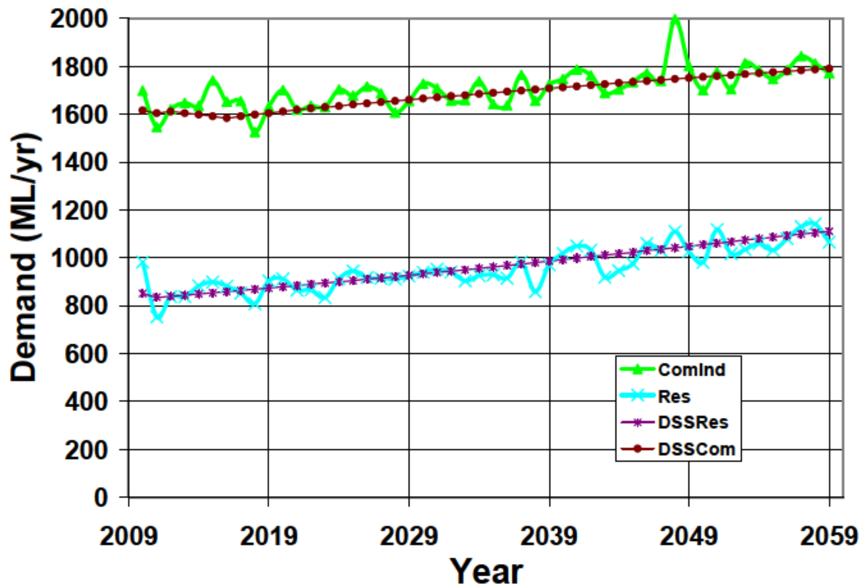

Figure B- 30: Verification of the Water Demands Generated by PURRS against the DSS results for Young

B.6.1 SUMMARY OF WATER DEMANDS IN 2050

The averages of all replicates of water demands for 2050 in each scenario are shown in Table B- 12. Note that the scenario BCP_CC refers to the higher demand management scenario that is subject to incremental climate change.

Table B- 12: Summary of Average Results from the Replicates of Water Demands for 2050

LOCATION	EXPECTED WATER DEMANDS IN 2050 (ML/YR)[12]			
	BASE	BCP1	BCP2	BCP2_CC
Bathurst	7,168	6,292	6,196	6,380
Blayney - Carcoar	1,025	998	967	1,067
Boorowa	178	175	169	171
Canowindra	379	368	342	369
Condobolin	1,131	1,039	1,014	1,193
Cowra - Koorawatha	3527	3446	3240	3386
Crookwell	334	307	306	307
Cudal – Cargo - Manildra	310	302	293	305
Cumnock - Yeoval	194	178	175	181
Forbes	3,411	3,306	3,211	3,438
Gooloogong- Eugowra	187	192	177	181
Grenfell	487	474	459	496
Lake Cargelligo	584	539	526	647
Lithgow - Portland	1,751	1,672	1,635	1,720
Molong	370	345	324	349
Murrumburrah - Harden	850	814	767	818
Oberon	946	920	891	951
Orange	6,900	5,941	5,656	5,994
Parkes	7,832	7,366	7,276	7,810
Wellington - Geurie	1,801	1,736	1,621	1,782
Young	2,510	2,381	2,293	2,436

Table B- 12 shows that the demand management scenarios BCP1 and BCP2 reduce water demands, as expected, in comparison to the base case. Climate change is expected to produce higher water demands in 2050 for the BCP2 demand management scenario. However, the increases in water demands generated by climate change are, mostly, less than the reductions in water demand created by the BCP2 scenario. The use of water efficient appliances and rainwater tanks will mitigate the impacts of climate change on water demands.

The results in Table B- 12 are a summary of the average trends of the water demand inputs to the network linear analysis using WATHNET.

[12] The demands generated using the PURRS model are slightly different from those generated using the DSM-DSS model (due to more detailed modelling of the impact of rainwater tanks through the BASIX scheme) in TABLE B-13. The PURRS model demands were the demands used in hydrological assessment.

B.6.2 CONCLUSIONS

This project has successfully utilised long climate records, socio-economic information, the DSS and continuous simulation methodologies to generate water demand sequences for input to the network linear program WATHNET. The analysis has incorporated water efficient appliances and rainwater tanks in scenarios that relate to the BASIX legislation and in a scenario with extended demand management efforts.

The results from this analysis show the expected variation of water demands in response to climate variation and climate change that are important for the analysis of water security. A strategy to include water efficient appliances and rainwater tanks in towns, in accordance with BASIX legislation, will make a significant contribution to mitigating the impacts of climate change.

B.7 OUTCOMES

The outcomes of this assessment are summarised in the following tables. In the absence of any demand management effort the water demand in the urban communities considered in the study can be expected to rise approximately 22% over the 50 year planning horizon. A significant proportion (over one half) of this growth can be offset with the continued implementation of existing demand management programs and the introduction of new programs.

Table B- 13: CENTROC Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	142,895	147,383	150,500	152,485	153,588	154,525	155,466	156,367	157,262	158,161	159,090
BASELINE DEMAND (ML)	35,354	36,475	37,425	38,213	38,876	39,532	40,209	40,895	41,595	42,312	43,049
CURRENT PROGRAMS (ML)	35,261	33,934	34,409	35,011	35,543	36,083	36,643	37,215	37,798	38,392	39,001
MAXIMUM CONSERVATION (ML)	35,261	33,071	33,514	34,220	34,738	35,262	35,805	36,360	36,927	37,503	38,093

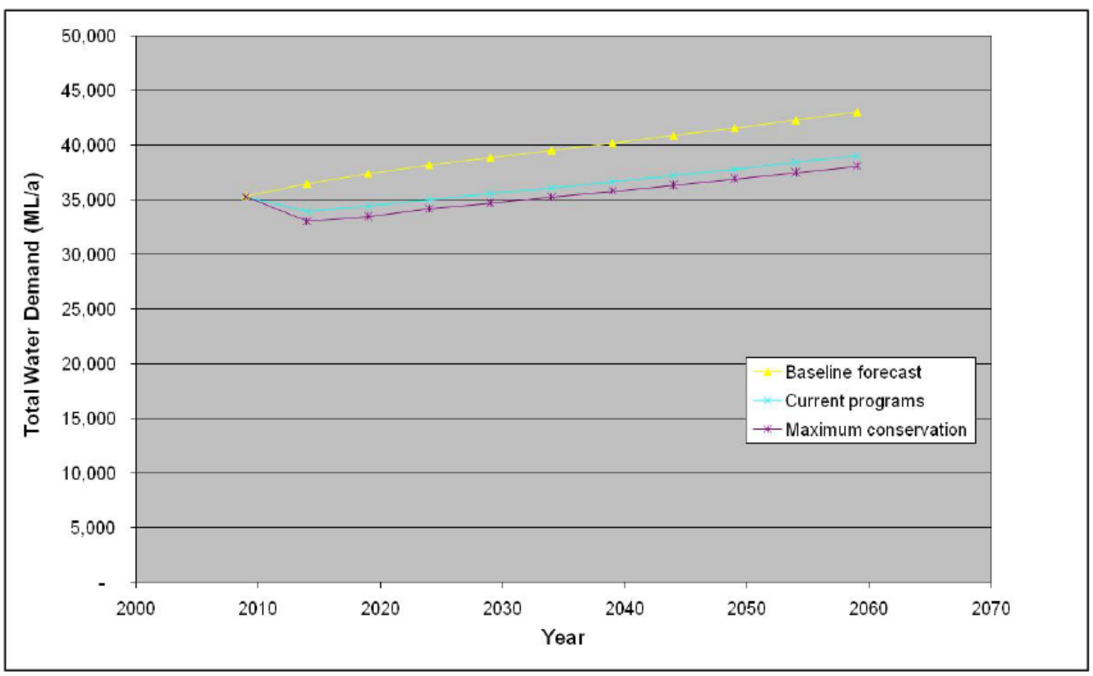

Figure B- 2: CENTROC Annual Average Demand - Scenario Comparison (ML/a)

The following section includes the key inputs and outcomes of the water demand forecasting for each node. Each section contains the following:

STUDY AREA

- List of towns and centres included in the node
- Indication of the ABS population data set used (e.g. Local Government Area, Urban Centre Locality etc). The identification of the most appropriate population is critical within the central west region as there are often properties outside of the area serviced by the reticulated water network.

KEY DATA INPUTS

The key data inputs section outlines the key inputs as known or assumed for 2009. The section covers the following:

- Population;
- Numbers of residential and non-residential accounts;
- Bulk water production (L/p/day);
- System water losses (% of total water production);
- Consumption rates for residential and non-residential accounts (L/account/day);
- Internal and external water use ratio for existing residential accounts; and
- Internal to external water use ratio for new residential accounts.

DEMAND FORECASTING OUTCOMES

The Demand Forecasting Outcomes section summarises:

- The forecast annual water demand (ML/annum) from 2009 to 2059.
- The forecast per capita water demand (Litres/ person/ day) from 2009 to 2059.

Where historical production and consumption records were available, they are included for comparison.

Included in these summaries and graphs are the forecasts of the Base Case, Current Programs and Maximum Conservation scenarios. It can be seen from these graphs that the Current Programs and Maximum Conservation scenarios generally result in reduced consumption per capita, resulting in a reduction in the level of increase in total annual demand over the 50 year period.

B.7.1 BATHURST

This study covered the area serviced by the Bathurst Water Supply Scheme. The population used for the study was the Urban Centre Locality population to account for the population within the Local Government Area outside of the serviced area.

Table B- 14: Bathurst Population and Account Numbers

PARAMETER	2009 INPUTS / ASSUMPTIONS
Population	30,054
Total Accounts	15,393
Residential Accounts	14,635
Commercial Accounts	754
Industrial Accounts	3
Other Accounts	0

Table B- 15: Bathurst Consumption Rates (2009)

PARAMETER	2009 INPUTS / ASSUMPTIONS
Production	
Bulk Production (litres / person / day)	584.9
Losses (% of production)	35.0
Consumption (litres /account / day)	
Residential (existing)	662.5
Residential (new)	643.1
Commercial	2,262.5
Industrial	7,759.2
Other	0

Table B- 16: Bathurst Residential Water Use Breakdown

RESIDENTIAL USAGE	L/ACC/DAY)	%
EXISTING HOUSES		
Internal	379.1	57.2%
External	283.3	42.8%
NEW HOUSES		
Internal	359.7	55.9%
External	283.3	44.1%
Air conditioning demand (Litres / unit / day)	42.8	

Table B- 17: Bathurst Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	30,054	31,100	31,959	32,451	32,652	32,717	32,739	32,746	32,748	32,749	32,749
BASELINE DEMAND (ML)	6,420	6,662	6,881	7,037	7,142	7,226	7,304	7,381	7,459	7,538	7,618
CURRENT PROGRAMS (ML)	6,402	5,961	6,027	6,136	6,214	6,279	6,341	6,403	6,467	6,532	6,597
MAXIMUM CONSERVATION (ML)	6,402	5,855	5,923	6,043	6,121	6,186	6,248	6,310	6,373	6,437	6,501

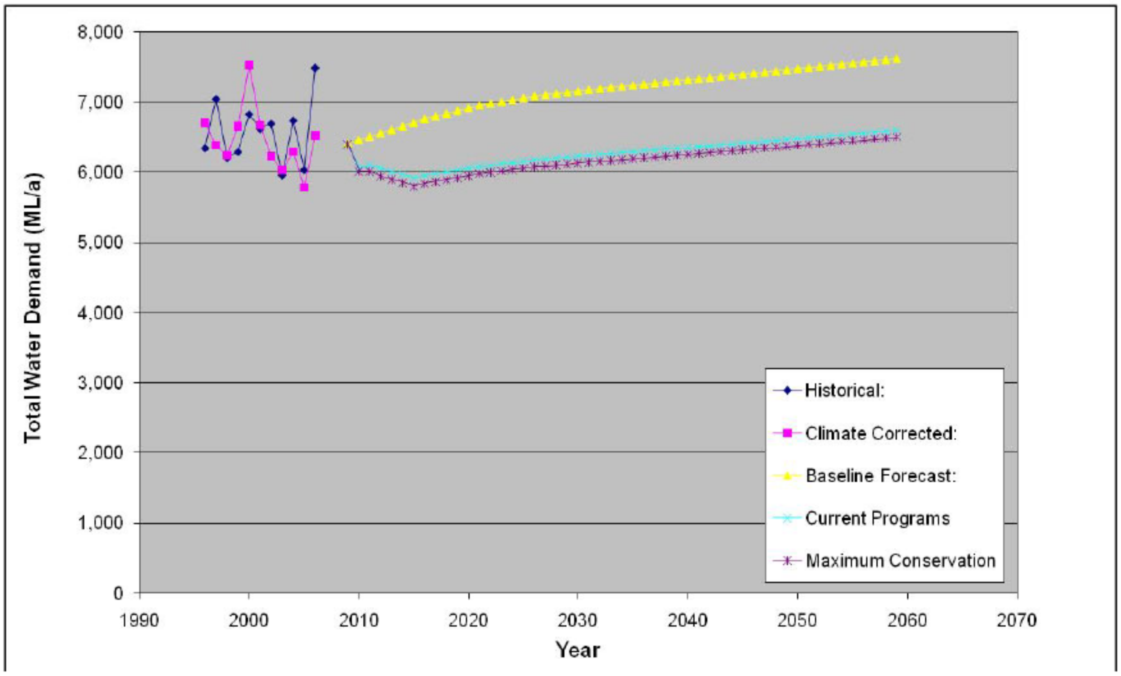

Figure B- 31: Bathurst Annual Average Demand - Scenario Comparison (ML/a)

B.7.2 BLAYNEY-CARCOAR

This study covered the areas of Blayney, Millthorpe, Carcoar, Lyndhurst, Mandurama and Garland, which are serviced by Central Tablelands Water. The population used for the study is the sum of the serviced populations within these centres.

Table B- 18: Blayney - Carcoar Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	4143
Total Accounts	2,487.21
Residential Accounts	1,687.21
Commercial Accounts	48
Industrial Accounts	691
Other Accounts	61

Table B- 19: Blayney -Carcoar Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	600.4
Losses (% of production)	8.0
Consumption (litres / account / day)	
Residential (existing)	732
Residential (new)	709
Commercial	1,763
Industrial	1,222
Other	1,967

Table B- 20: Blayney - Carcoar Residential Water Use Breakdown

RESIDENTIAL USAGE	L/ACC/DAY)	%
EXISTING HOUSES		
Internal	440.60	60.2%
External	291.80	39.8%
NEW HOUSES		
Internal	417.40	37.0%
External	709.20	63.0%
Air conditioning demand (Litres / unit / day)		30.6

Table B- 21: Blayney Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	4,143	4,232	4,308	4,359	4,393	4,416	4,433	4,445	4,453	4,459	4,464
BASELINE DEMAND (ML)	907	927	946	962	976	989	1,001	1,012	1,023	1,033	1,044
CURRENT PROGRAMS (ML)	905	905	917	930	942	953	963	974	984	993	1,003
MAXIMUM CONSERVATION (ML)	905	866	878	898	910	921	932	942	952	961	970

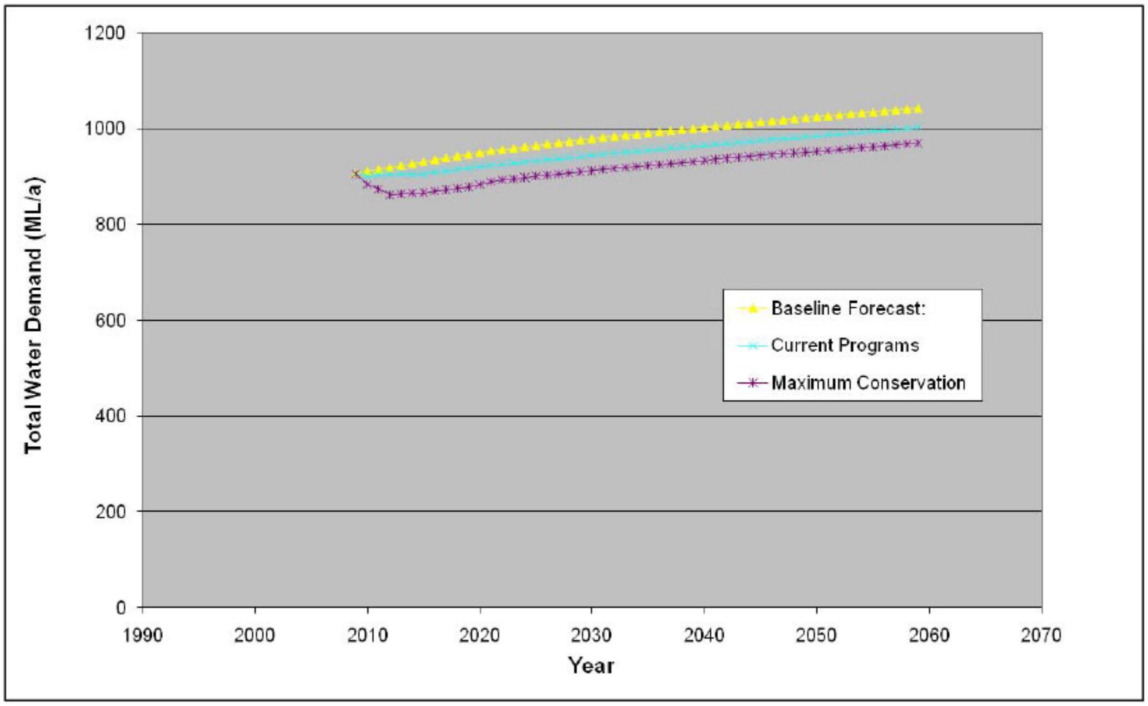

Figure B- 32: Blayney - Carcoar Annual Average Demand - Scenario Comparison (ML/a)

B.7.3 BOOROWA

This study covered the area of Boorowa covered by the Boorowa Water Scheme. The population used is the ABS data for the Urban Centre Locality of Boorowa. The Local Government Area population contains people not served by the scheme.

Table B- 22: Boorowa Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	1,075
Total Accounts	852
Residential Accounts	622
Commercial Accounts	174
Industrial Accounts	37
Other Accounts	19

Table B- 23: Boorowa Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	452.8
Losses (% of production)	15%
Consumption (litres / account / day)	
Residential (existing)	414
Residential (new)	398
Commercial	663
Industrial	711
Other	753

Table B- 24: Boorowa Residential Water Use Breakdown

RESIDENTIAL USAGE	(L/acc/day)	%
EXISTING HOUSES		
Internal	320.39	77.4%
External	93.58	22.6%
NEW HOUSES		
Internal	304.61	76.5%
External	93.58	23.5%
Air conditioning demand (Litres / unit / day)		40.9

Table B- 25: Boorowa Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	1,075	1,082	1,084	1,079	1,069	1,058	1,044	1,027	1,007	982	954
BASELINE DEMAND (ML)	178	183	184	184	184	183	182	181	178	176	172
CURRENT PROGRAMS (ML)	177	174	173	174	173	172	171	170	168	165	162
MAXIMUM CONSERVATION (ML)	177	168	168	169	169	168	167	166	164	161	157

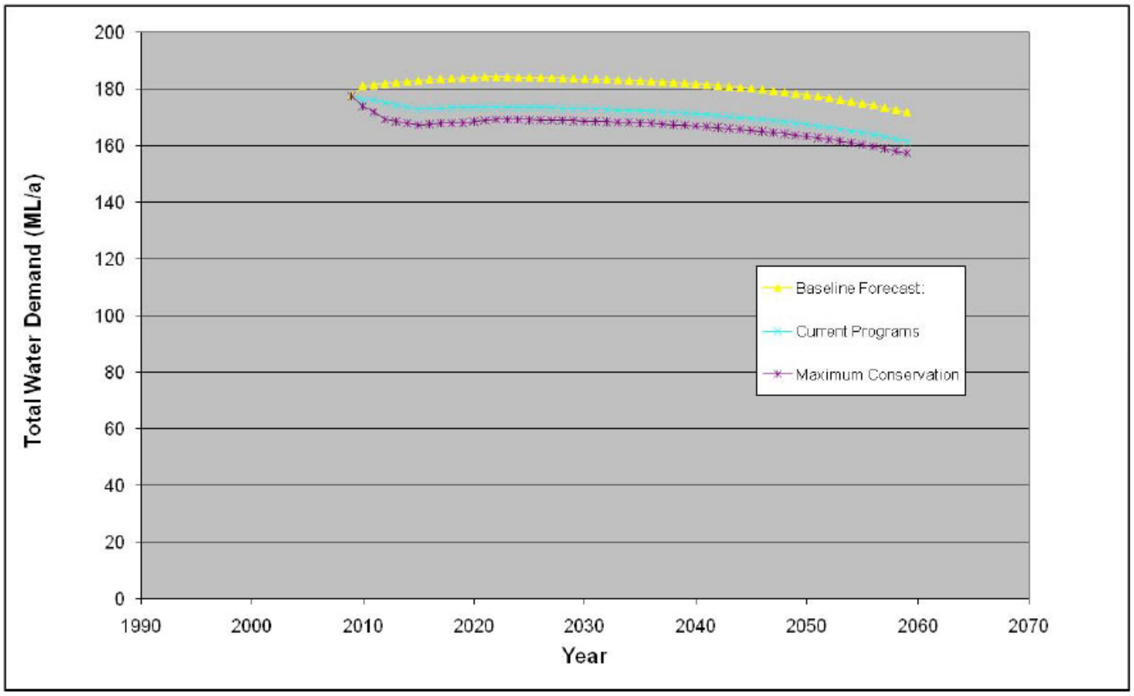

Figure B- 33: Boorowa Annual Average Demand - Scenario Comparison (ML/a)

B.7.4 CANOWINDRA

This study covered the areas of Canowindra and Woodstock serviced by the Central Tablelands Water Scheme. The population used for the study is the sum of the populations within these centres. The Local Government Area population contains people not served by the scheme.

Table B- 26: Canowindra Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	1,519
Total Accounts	821.9
Residential Accounts	622.43
Commercial Accounts	18
Industrial Accounts	251
Other Accounts	22

Table B- 27: Canowindra Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	600.4
Losses (% of production)	8.0
Consumption (litres / account / day)	
Residential (existing)	724
Residential (new)	701
Commercial	1,779
Industrial	1,234
Other	1,986

Table B- 28: Canowindra Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
EXISTING HOUSES		
Internal	438.00	60.5%
External	286.30	39.5%
NEW HOUSES		
Internal	415.00	59.2%
External	286.30	40.8%
Air conditioning demand (Litres / unit / day)	47.9	

Table B- 29: Canowindra Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	1,519	1,552	1,580	1,598	1,611	1,619	1,625	1,630	1,633	1,635	1,637
BASELINE DEMAND (ML)	332	340	348	354	359	364	369	373	377	381	385
CURRENT PROGRAMS (ML)	331	331	336	341	345	350	354	357	361	365	368
MAXIMUM CONSERVATION (ML)	331	317	322	330	334	338	342	346	350	353	357

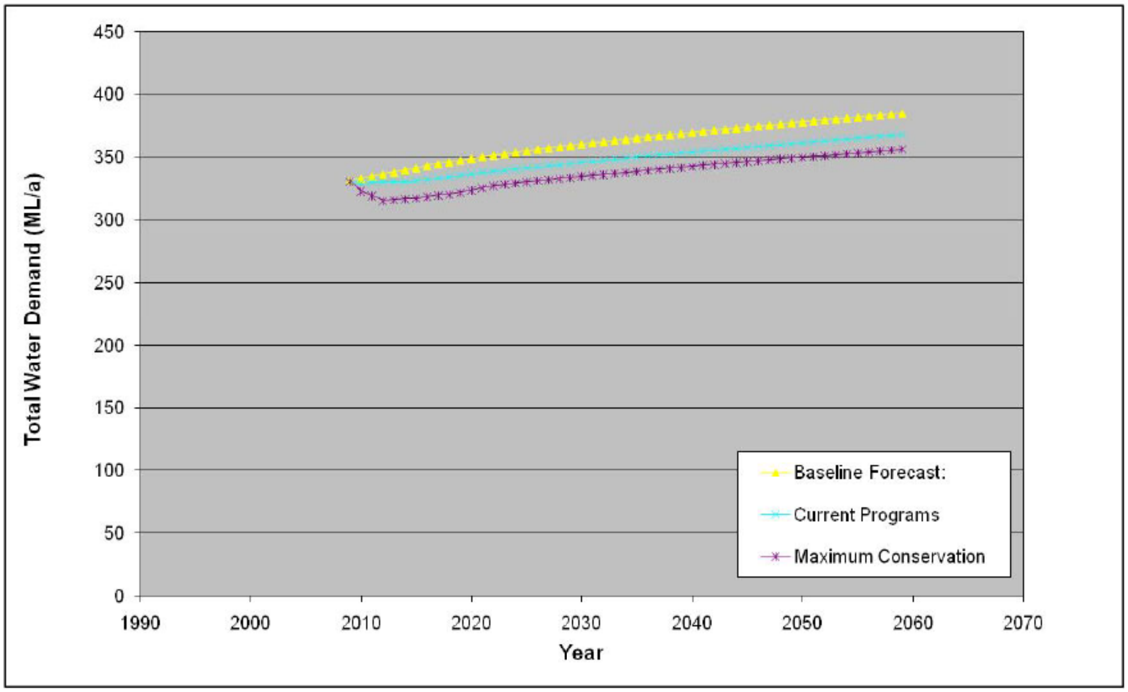

Figure B- 34: Canowindra Annual Average Demand - Scenario Comparison (ML/a)

B.7.5 CONDOBOLIN

This study covered the areas of Condobolin serviced by the Lachlan Water Scheme. The population used for the study is the population within the urban centre of Condobolin (similar to the ABS Urban Centre Locality population). The Local Government Area population contains people not served by the scheme.

Table B- 30: Condobolin Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	2,882
Total Accounts	1,751
Residential Accounts	1,366
Commercial Accounts	193
Industrial Accounts	0
Other Accounts	193

Table B- 31: Condobolin Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	839.2
Losses (% of production)	0.15
Consumption (litres / account / day)	
Residential (existing)	1,030.8
Residential (new)	1,010.8
Commercial	1,120.4
Industrial	0.0
Other	2,240.8

Table B- 32: Condobolin Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
Existing Houses		
Internal	387.69	37.6%
External	643.08	62.4%
New Houses		
Internal	367.75	36.4%
External	643.08	63.6%
Air conditioning demand (Litres / unit / day)		52.6

Table B- 33: Condobolin Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	2,882	2,937	2,994	3,055	3,121	3,189	3,260	3,335	3,413	3,495	3,581
BASELINE DEMAND (ML)	883	922	957	993	1,030	1,068	1,109	1,151	1,195	1,242	1,291
CURRENT PROGRAMS (ML)	880	851	870	895	923	951	982	1,013	1,046	1,081	1,116
MAXIMUM CONSERVATION (ML)	880	823	842	872	899	927	957	988	1,021	1,055	1,090

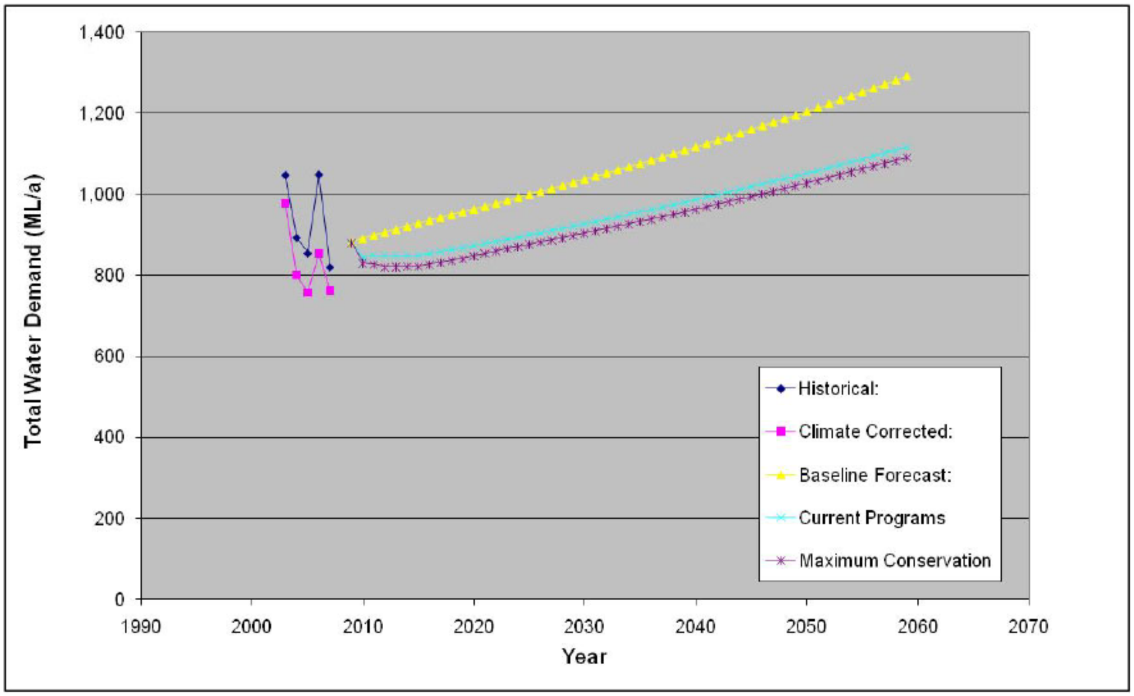

Figure B- 35: Condobolin Annual Average Demand - Scenario Comparison (ML/a)

B.7.6 COWRA-KOORAWATHA

This study covered the areas of Cowra, Bendick Murrell, Brundah, Greenethorpe, Koorawatha, Mogongong and Wattamondra. The population used for the study is the sum of the populations within these centres. The Local Government Area population contains people not served by the scheme.

Table B- 34: Cowra- Koorawatha Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	8,837
Total Accounts	5,912
Residential Accounts	5,240
Commercial Accounts	163
Industrial Accounts	200
Other Accounts	309

Table B- 35: Cowra- Koorawatha Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	878.7
Losses (% of production)	15.0
Consumption (litres / account / day)	
Residential (existing)	781
Residential (new)	765
Commercial	3635
Industrial	3632
Other	3850

Table B- 36: Cowra- Koorawatha Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
EXISTING HOUSES		
Internal	322.74	41.3%
External	458.17	58.7%
NEW HOUSES		
Internal	306.81	40.1%
External	458.17	59.9%
Air conditioning demand (Litres / unit / day)	49.2	

Table B- 37: Cowra-Koorawatha Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	8,837	8,906	8,985	9,044	9,093	9,152	9,222	9,307	9,411	9,535	9,687
BASELINE DEMAND (ML)	2,836	2,885	2,939	2,991	3,043	3,100	3,163	3,233	3,310	3,397	3,494
CURRENT PROGRAMS (ML)	2,826	2,713	2,740	2,781	2,824	2,872	2,924	2,981	3,044	3,114	3,191
MAXIMUM CONSERVATION (ML)	2,826	2,616	2,642	2,700	2,743	2,790	2,842	2,898	2,960	3,029	3,105

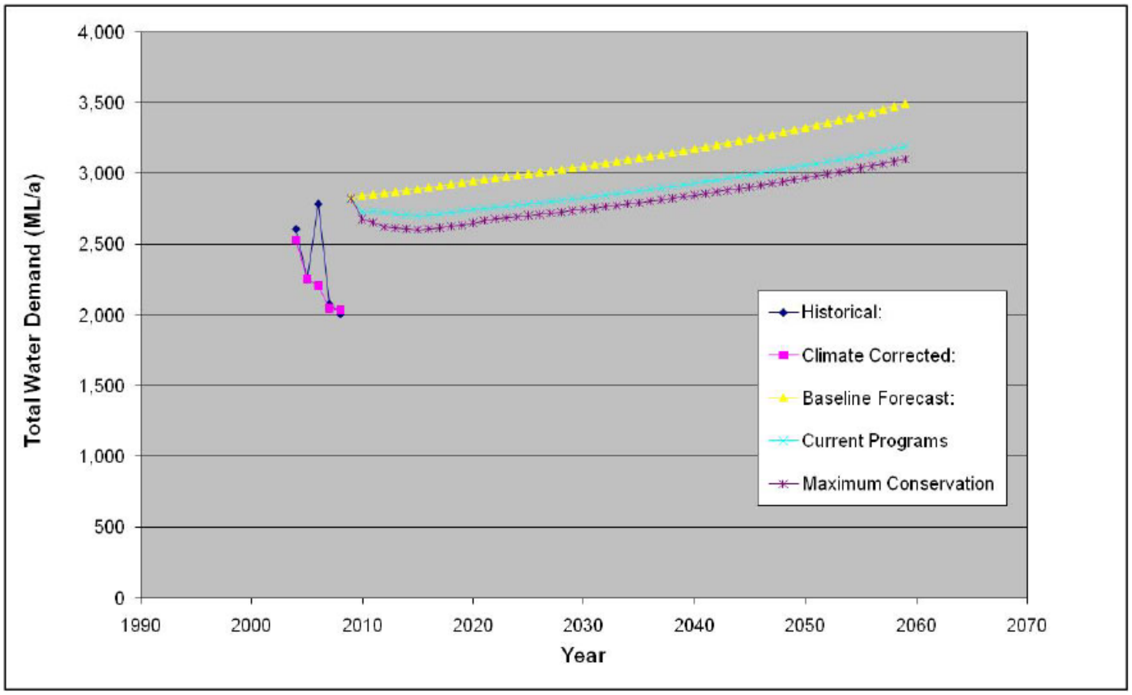

Figure B- 36: Cowra- Koorawatha Annual Average Demand - Scenario Comparison (ML/a)

B.7.7 CROOKWELL

This study covered the areas of Crookwell. The population used for the study is the sum of the populations within these centres. The Local Government Area population contains people not served by the scheme.

Table B- 38: Crookwell Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	1,999
Total Accounts	1,773
Residential Accounts	1,288
Commercial Accounts	360
Industrial Accounts	83
Other Accounts	44

Table B- 39: Crookwell Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	452.8
Losses (% of production)	15.0
Consumption (litres / account / day)	
Residential (existing)	372
Residential (new)	357
Commercial	598
Industrial	598
Other	598

Table B- 40: Crookwell Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
EXISTING HOUSES		
Internal	302.6	81.3%
External	69.5	18.7%
NEW HOUSES		
Internal	287.9	80.6%
External	69.5	19.4%
Air conditioning demand (Litres / unit / day)		27.2

Table B- 41: Crookwell Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	1,999	2,010	2,013	2,007	1,999	1,990	1,981	1,970	1,960	1,948	1,936
BASELINE DEMAND (ML)	331	332	332	332	332	333	333	333	334	334	335
CURRENT PROGRAMS (ML)	330	308	306	305	305	305	306	306	306	307	307
MAXIMUM CONSERVATION (ML)	330	298	296	297	297	298	298	298	299	299	299

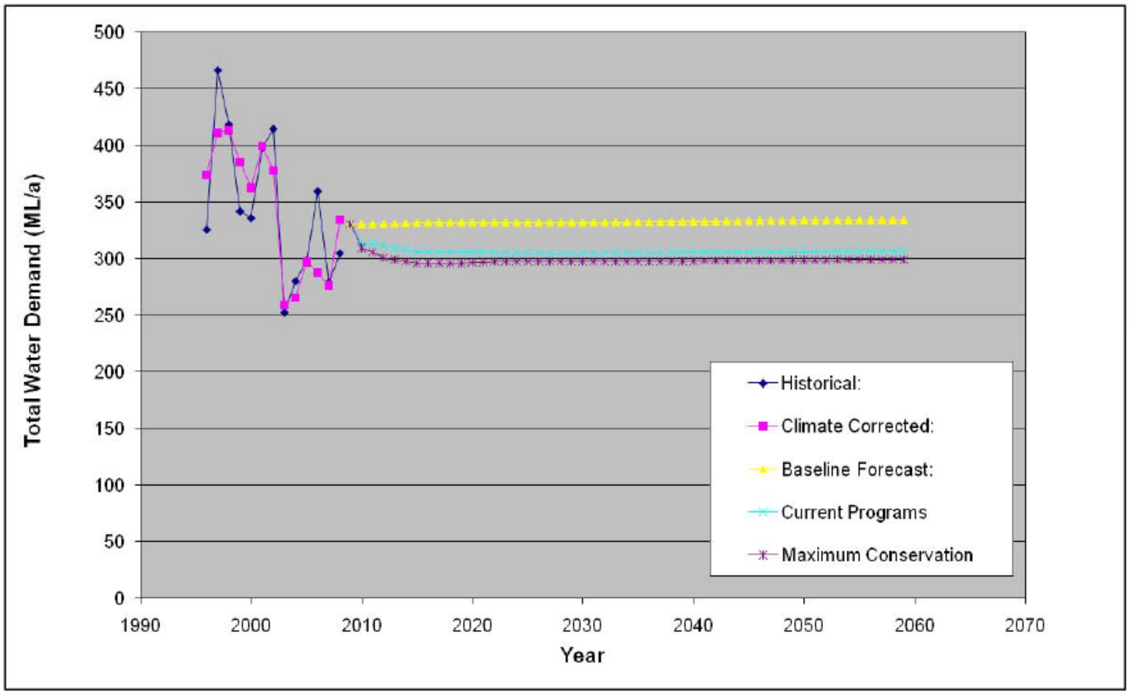

Figure B- 37: Crookwell Annual Average Demand - Scenario Comparison (ML/a)

B.7.8 CUMNOCK

This study covered the areas of Cumnock and Yeoval. The population used for the study is the sum of the populations within these centres. The Local Government Area population contains people not served by the scheme.

Table B- 42: Cumnock Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	601
Total Accounts	348.9
Residential Accounts	299.9
Commercial Accounts	40
Industrial Accounts	
Other Accounts	9

Table B- 43: Cumnock Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	806.1
Losses (% of production)	31.7
Consumption (litres / account / day)	
Residential (existing)	770
Residential (new)	752
Commercial	2029
Industrial	0
Other	2029

Table B- 44: Cumnock Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
EXISTING HOUSES		
Internal	371.40	48.2%
External	399.10	51.8%
NEW HOUSES		
Internal	352.50	46.9%
External	399.10	53.1%
Air conditioning demand (Litres / unit / day)		46.7

Table B- 45: Cumnock Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	601	610	616	618	618	618	618	618	618	618	618
BASELINE DEMAND (ML)	177	181	184	187	189	191	193	195	197	199	201
CURRENT PROGRAMS (ML)	176	169	169	171	173	174	176	178	180	182	184
MAXIMUM CONSERVATION (ML)	176	164	165	167	169	171	173	174	176	178	180

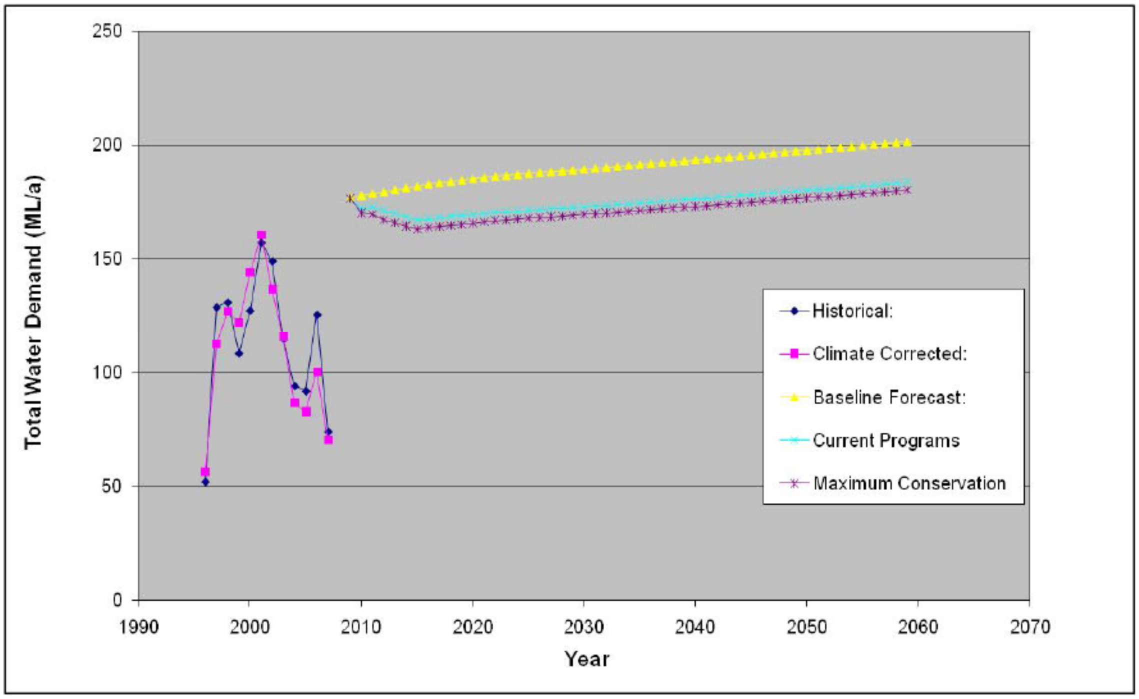

Figure B- 38: Cumnock Annual Average Demand - Scenario Comparison (ML/a)

B.7.9 CUDAL / CARGO / MANILDRA

This study covered the areas of Cudal, Cargo and Manildra served by the Central Tablelands Water Scheme. The population used for the study is the sum of the populations within these centres. The Local Government Area population contains people not served by the scheme.

Table B- 46: Cudal / Cargo / Manildra Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	1187
Total Accounts	716.25
Residential Accounts	488.25
Commercial Accounts	14
Industrial Accounts	197
Other Accounts	17

Table B- 47: Cudal / Cargo / Manildra Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	600.4
Losses (% of production)	8.0
Consumption (litres / account / day)	
Residential (existing)	725
Residential (new)	702
Commercial	1763
Industrial	1222
Other	1967

Table B- 48: Cudal / Cargo / Manildra Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
EXISTING HOUSES		
Internal	436.80	60.2%
External	288.30	39.8%
NEW HOUSES		
Internal	413.90	58.9%
External	288.30	41.1%
Air conditioning demand (Litres / unit / day)		46.0

Table B- 49: Cudal / Cargo / Manildra Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	1,187	1,212	1,234	1,249	1,258	1,265	1,270	1,273	1,276	1,278	1,279
BASELINE DEMAND (ML)	260	266	272	277	282	285	289	292	295	299	302
CURRENT PROGRAMS (ML)	259	259	263	267	270	274	277	280	283	286	288
MAXIMUM CONSERVATION (ML)	259	248	252	258	262	265	268	271	274	277	279

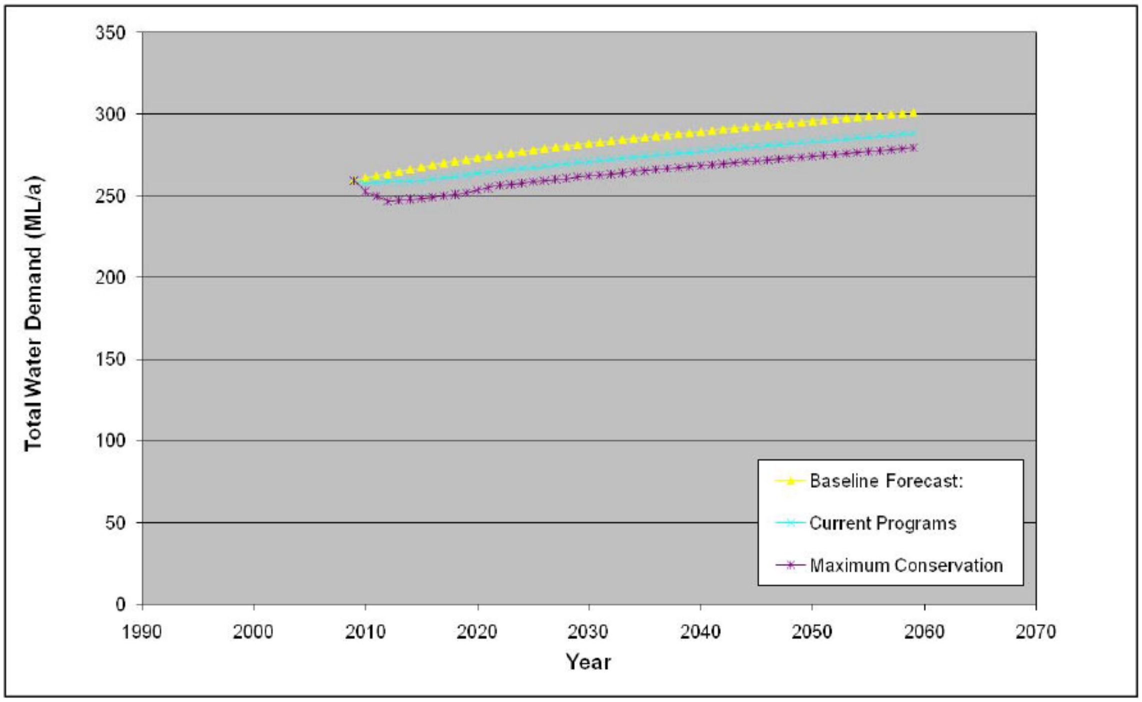

Figure B- 39: Cudal / Cargo / Manildra Annual Average Demand - Scenario Comparison (ML/a)

B.7.10 FORBES

This study covered the areas of Forbes, Albert, Tottenham, Bogan Gate, Gunningbland, Trundle and Tullamore serviced by the Forbes, Tottenham and Trundle water schemes. The population used for the study is the sum of the populations within these centres. The Local Government Area population contains people not served by the scheme.

Table B- 50: Forbes Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	8161
Total Accounts	3,483
Residential Accounts	3,170
Commercial Accounts	156
Industrial Accounts	59
Other Accounts	97

Table B- 51: Forbes Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	915.1
Losses (% of production)	15
Consumption (litres / account / day)	
Residential (existing)	852
Residential (new)	828
Commercial	2900
Industrial	11003
Other	26001

Table B- 52: Forbes Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
EXISTING HOUSES		
Internal	455.40	58.7%
External	320.20	41.3%
NEW HOUSES		
Internal	431.30	57.4%
External	320.20	42.6%
Air conditioning demand (Litres / unit / day)		51.8

Table B- 53: Forbes Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	8,161	8,244	8,323	8,382	8,422	8,449	8,467	8,480	8,489	8,495	8,499
BASELINE DEMAND (ML)	2,761	2,775	2,819	2,860	2,897	2,930	2,962	2,992	3,020	3,048	3,074
CURRENT PROGRAMS (ML)	2,755	2,686	2,703	2,735	2,764	2,792	2,819	2,844	2,869	2,893	2,917
MAXIMUM CONSERVATION (ML)	2,755	2,568	2,586	2,641	2,671	2,698	2,725	2,750	2,775	2,799	2,822

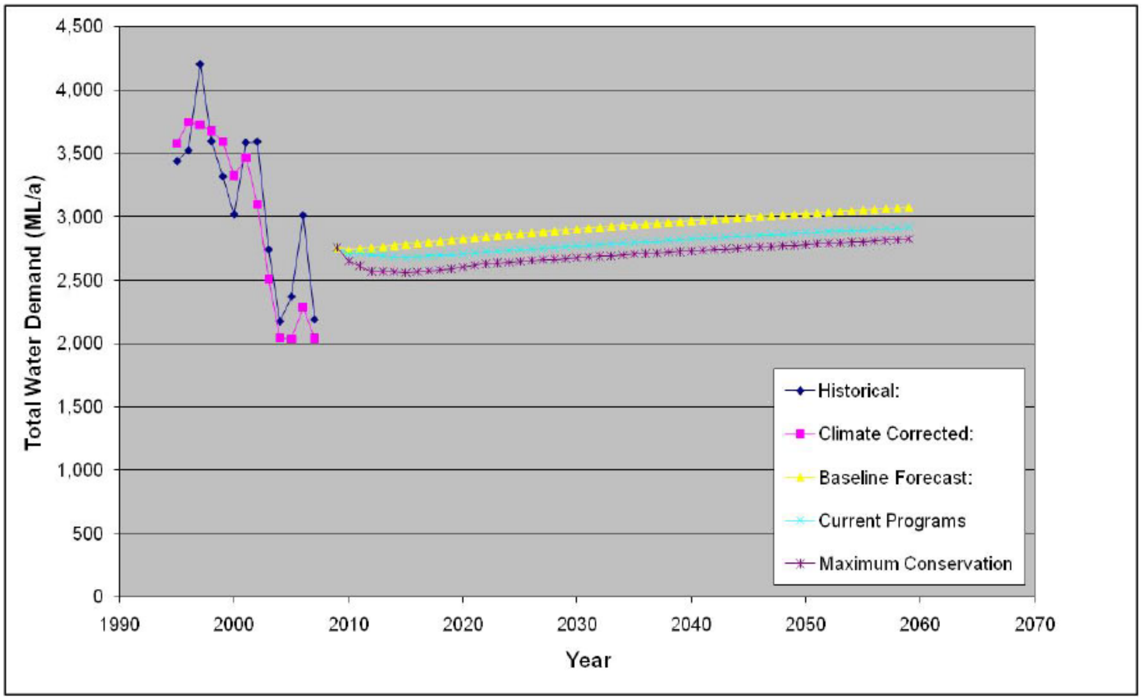

Figure B- 40: Forbes Annual Average Demand - Scenario Comparison (ML/a)

B.7.11 GOOLOOGONG / EUGOWRA

This study covered the areas of Gooloogong and Eugowra served by the Central Tablelands Water Scheme. The population used for the study is the sum of the populations within these centres. The Local Government Area population contains people not served by the scheme.

Table B- 54: Gooloogong - Eugowra Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	713
Total Accounts	429.32
Residential Accounts	292.88
Commercial Accounts	8
Industrial Accounts	118
Other Accounts	10

Table B- 55: Gooloogong - Eugowra Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	600.4
Losses (% of production)	8
Consumption (litres / account / day)	
Residential (existing)	726
Residential (new)	703
Commercial	1780
Industrial	1234
Other	1986

Table B- 56: Gooloogong - Eugowra Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
EXISTING HOUSES		
Internal	438.90	60.4%
External	287.20	39.6%
NEW HOUSES		
Internal	415.80	59.1%
External	287.20	40.9%
Air conditioning demand (Litres / unit / day)	47.9	

Table B- 57: Gooloogong - Eugowra Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	713	728	741	750	756	760	763	765	766	767	768
BASELINE DEMAND (ML)	156	159	163	166	168	170	172	174	176	178	180
CURRENT PROGRAMS (ML)	155	155	158	160	162	164	166	167	169	171	172
MAXIMUM CONSERVATION (ML)	155	149	151	155	157	158	160	162	164	165	167

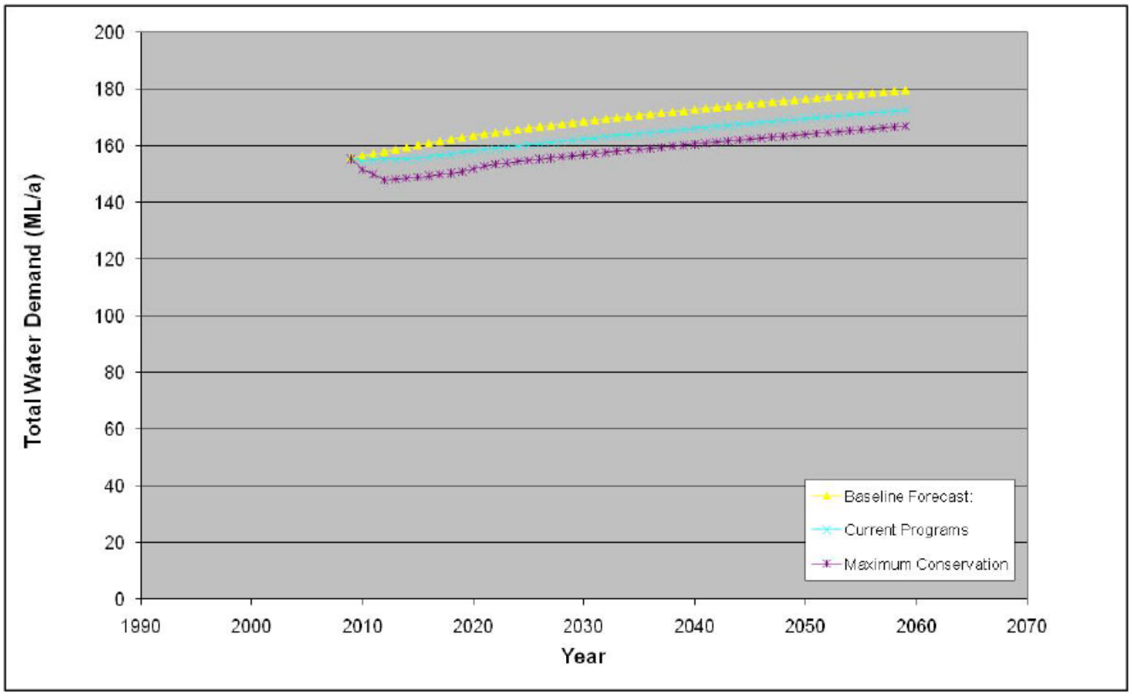

Figure B- 41: Gooloogong - Eugowra Annual Average Demand - Scenario Comparison (ML/a)

B.7.12 GRENFELL

This study covered the area of Grenfell serviced by the Central Tablelands Water Scheme. The population used for the study is the population within the urban centre. The Local Government Area population contains people not served by the scheme.

Table B- 58: Grenfell Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	2018
Total Accounts	1218.6039
Residential Accounts	828.66
Commercial Accounts	24
Industrial Accounts	337
Other Accounts	30

Table B- 59: Grenfell Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	600.4
Losses (% of production)	8
Consumption (litres / account / day)	
Residential (existing)	723
Residential (new)	701
Commercial	1763
Industrial	1222
Other	1967

Table B- 60: Grenfell Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
EXISTING HOUSES		
Internal	437.60	60.5%
External	285.90	39.5%
NEW HOUSES		
Internal	414.50	37.2%
External	700.50	62.8%
Air conditioning demand (Litres / unit / day)		46.3

Table B- 61: Grenfell Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	2,018	2,062	2,099	2,124	2,140	2,152	2,160	2,165	2,170	2,172	2,174
BASELINE DEMAND (ML)	441	452	463	471	479	486	492	498	503	508	513
CURRENT PROGRAMS (ML)	440	440	447	453	459	465	470	476	481	485	490
MAXIMUM CONSERVATION (ML)	440	422	428	438	444	450	455	460	465	470	475

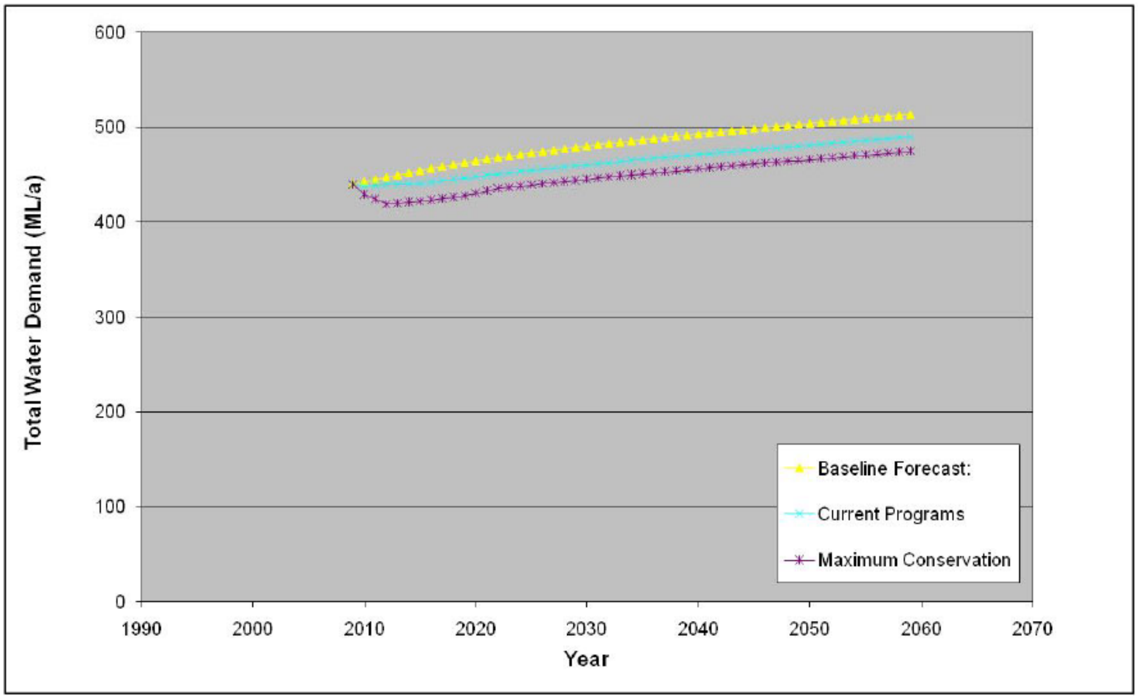

Figure B- 42: Grenfell Annual Average Demand - Scenario Comparison (ML/a)

B.7.13 LAKE CARGELLIGO

This study covered the areas of Lake Cargelligo, Murrin Bridge and Tullibigeal serviced by the Lachlan Water Scheme. The population used for the study is the population within the urban centre of Condobolin (similar to the ABS Urban Centre Locality population). The Local Government Area population contains people not served by the scheme.

Table B- 62: Lake Cargelligo Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	1398
Total Accounts	514
Residential Accounts	451
Commercial Accounts	0
Industrial Accounts	0
Other Accounts	64

Table B- 63: Lake Cargelligo Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	827.3
Losses (% of production)	0.15
Consumption (litres / account / day)	
Residential (existing)	1515
Residential (new)	1486
Commercial	1647
Industrial	0
Other	3293

Table B- 64: Lake Cargelligo Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
EXISTING HOUSES		
Internal	539.11	35.6%
External	975.74	64.4%
NEW HOUSES		
Internal	509.81	34.3%
External	975.74	65.7%
Air conditioning demand (Litres / unit / day)		53.8

Table B- 65: Lake Cargelligo Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	1,398	1,425	1,452	1,482	1,514	1,547	1,581	1,618	1,656	1,695	1,737
BASELINE DEMAND (ML)	428	447	464	482	500	518	538	558	580	603	626
CURRENT PROGRAMS (ML)	427	412	421	434	447	461	475	490	506	523	540
MAXIMUM CONSERVATION (ML)	427	399	408	422	435	449	463	478	494	510	527

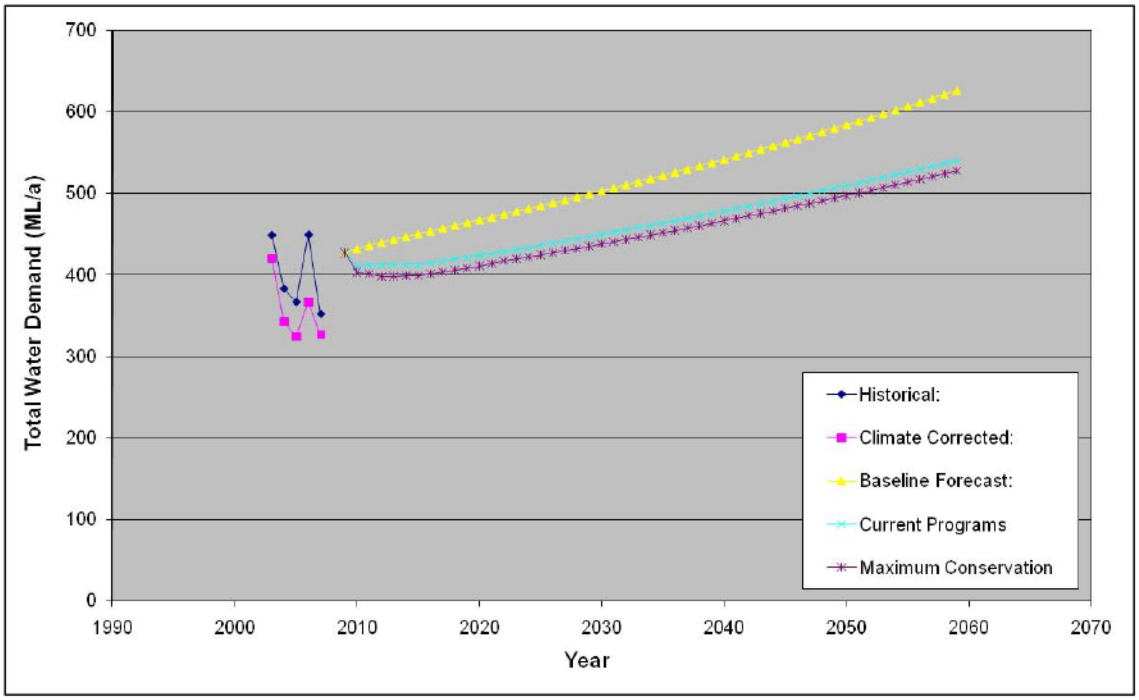

Figure B- 43: Lake Cargelligo Annual Average Demand - Scenario Comparison (ML/a)

B.7.14 LITHGOW / PORTLAND

This study covered the areas of Lithgow and Portland. The Fish River Water Supply also supplies Wallerawang, Marrangaroo, Glen Davis and Cullen Bullen; however these centres were not included in this demand node. The population used for the study is the sum of the populations within these centres. The LGA populations contain people not served by the scheme.

Table B- 66: Lithgow / Portland Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	11379
Total Accounts	7123.2
Residential Accounts	6646.2
Commercial Accounts	475
Industrial Accounts	2
Other Accounts	0

Table B- 67: Lithgow / Portland Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	431.8
Losses (% of production)	15
Consumption (litres / account / day)	
Residential (existing)	532
Residential (new)	516
Commercial	1325
Industrial	4360
Other	431.8

Table B- 68: Lithgow / Portland Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
EXISTING HOUSES		
Internal	326.95	38.0%
External	532.37	62.0%
NEW HOUSES		
Internal	310.76	37.6%
External	516.18	62.4%
Air conditioning demand (Litres / unit / day)		27.6

Table B- 69: Lithgow / Portland Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	11,379	11,516	11,611	11,616	11,544	11,484	11,460	11,441	11,407	11,356	11,301
BASELINE DEMAND (ML)	1,794	1,834	1,873	1,902	1,921	1,943	1,971	2,000	2,025	2,048	2,069
CURRENT PROGRAMS (ML)	1,788	1,761	1,774	1,793	1,808	1,826	1,849	1,875	1,899	1,920	1,940
MAXIMUM CONSERVATION (ML)	1,788	1,720	1,734	1,757	1,772	1,790	1,814	1,839	1,863	1,884	1,903

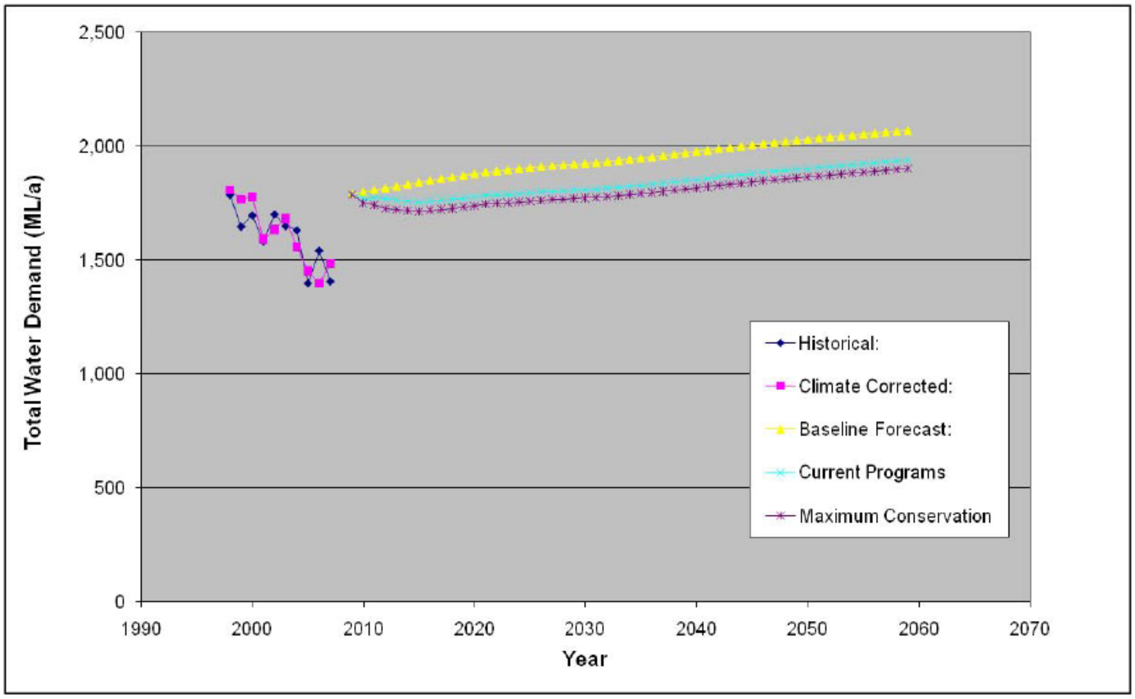

Figure B- 44: Lithgow / Portland Annual Average Demand - Scenario Comparison (ML/a)

B.7.15 MOLONG

This study covered the area of Molong serviced by the Cabonne Shire Council. The population used is that within the Molong centre. Areas outside of Molong within Cabonne Shire Council are addressed in other studies.

Table B- 70: Molong Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	1586
Total Accounts	863
Residential Accounts	733
Commercial Accounts	106
Industrial Accounts	24
Other Accounts	863

Table B- 71: Molong Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	411.34
Losses (% of production)	0.15
Consumption (litres / account / day)	
Residential (existing)	865
Residential (new)	848
Commercial	50
Industrial	0
Other	9

Table B- 72: Molong Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
EXISTING HOUSES		
Internal	342.68	39.6%
External	522.76	60.4%
NEW HOUSES		
Internal	325.52	38.4%
External	522.68	61.6%
Air conditioning demand (Litres / unit / day)	44.1	

Table B- 73: Molong population and annual average demand forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	1,586	1,630	1,675	1,701	1,712	1,721	1,732	1,741	1,750	1,760	1,769
BASELINE DEMAND (ML)	278	294	310	322	331	341	350	359	368	377	387
CURRENT PROGRAMS (ML)	277	272	280	288	295	302	309	316	324	331	338
MAXIMUM CONSERVATION (ML)	277	267	275	283	290	297	304	311	318	326	333

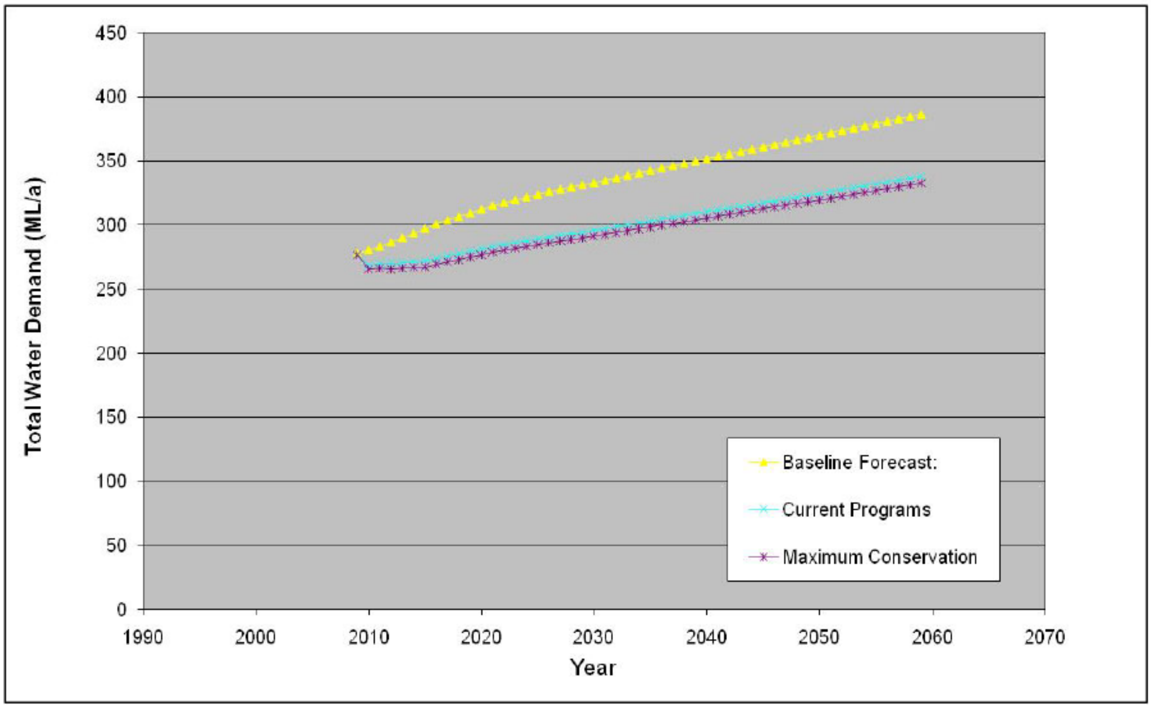

Figure B- 45: Molong Annual Average Demand - Scenario Comparison (ML/a)

B.7.16 MURRUMBURRAH (HARDEN)

This study covered the areas of Murrumburrah (Harden), Galong, Jugiong and Wombat serviced by Harden Water Utility and Goldenfields Water County Council. The population used for the study is the sum of the populations within these centres. The Local Government Area populations contain people not served by the scheme.

Table B- 74: Murrumburrah (Harden) Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	2373
Total Accounts	1617
Residential Accounts	1104
Commercial Accounts	51
Industrial Accounts	278
Other Accounts	184

Table B- 75: Murrumburrah (Harden) Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	965.5
Losses (% of production)	10%
Consumption (litres / account / day)	
Residential (existing)	735
Residential (new)	716
Commercial	2275
Industrial	2247
Other	2245

Table B- 76: Murrumburrah (Harden) Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
EXISTING HOUSES		
Internal	375.80	51.1%
External	359.20	48.9%
NEW HOUSES		
Internal	356.60	50.7%
External	347.09	49.3%
Air conditioning demand (Litres / unit / day)		42.8

Table B- 77: Murrumburrah (Harden) Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	2,243	2,249	2,252	2,251	2,249	2,249	2,249	2,249	2,249	2,249	2,249
BASELINE DEMAND (ML)	792	801	809	815	821	828	835	842	849	856	863
CURRENT PROGRAMS (ML)	790	771	775	781	787	793	799	806	813	819	826
MAXIMUM CONSERVATION (ML)	790	734	738	751	757	763	770	776	783	789	796

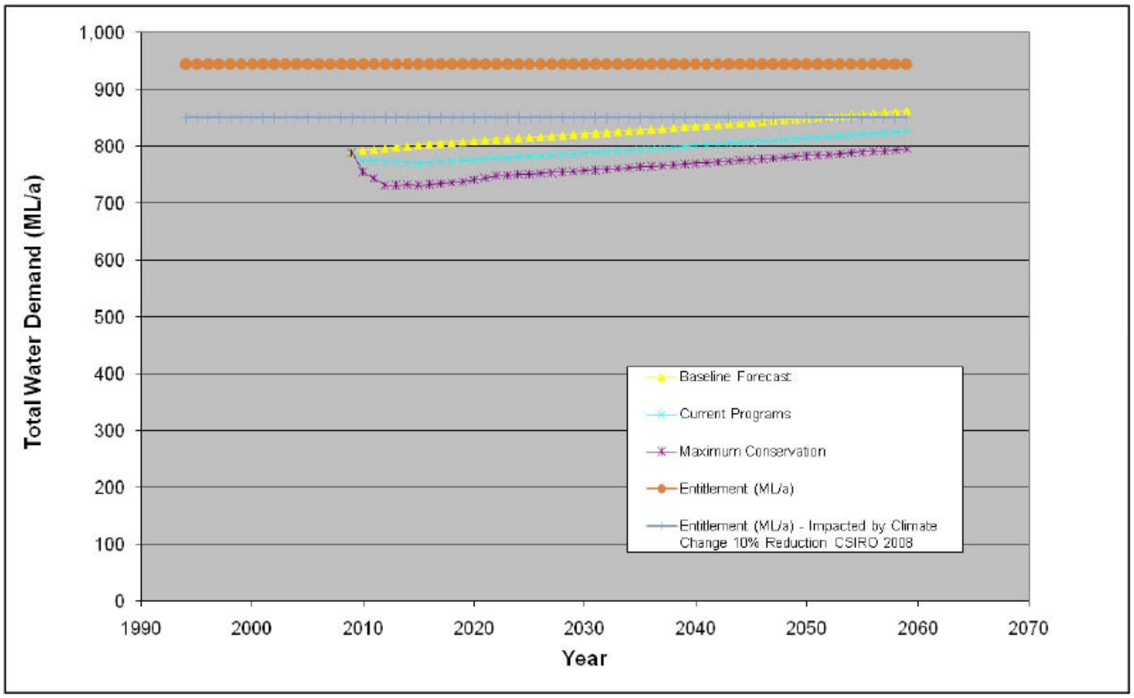

Figure B- 46: Murrumburrah (Harden) Annual Average Demand - Scenario Comparison (ML/a)

B.7.17 OBERON

This study covered the area of Oberon serviced by the Oberon Water Scheme. The population used for the study is the populations within the urban centre of Oberon. The Local Government Area populations contain people not served by the scheme.

Table B- 78: Oberon Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	2514
Total Accounts	1350
Residential Accounts	0.00
Commercial Accounts	67
Industrial Accounts	67
Other Accounts	1

Table B- 79: Oberon Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	816.9
Losses (% of production)	15%
Consumption (litres / account / day)	
Residential (existing)	691
Residential (new)	674
Commercial	1533
Industrial	2556
Other	821355

Table B- 80: Oberon Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
EXISTING HOUSES		
Internal	375.40	54.3%
External	315.80	45.7%
NEW HOUSES		
Internal	356.20	52.9%
External	317.70	47.1%
Air conditioning demand (Litres / unit / day)		20.9

Table B- 81: Oberon Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	2,514	2,581	2,637	2,663	2,668	2,667	2,667	2,667	2,667	2,667	2,667
BASELINE DEMAND (ML)	839	866	890	905	914	921	929	937	944	952	960
CURRENT PROGRAMS (ML)	837	842	857	869	877	883	890	897	904	911	918
MAXIMUM CONSERVATION (ML)	837	806	821	840	848	854	861	868	874	882	889

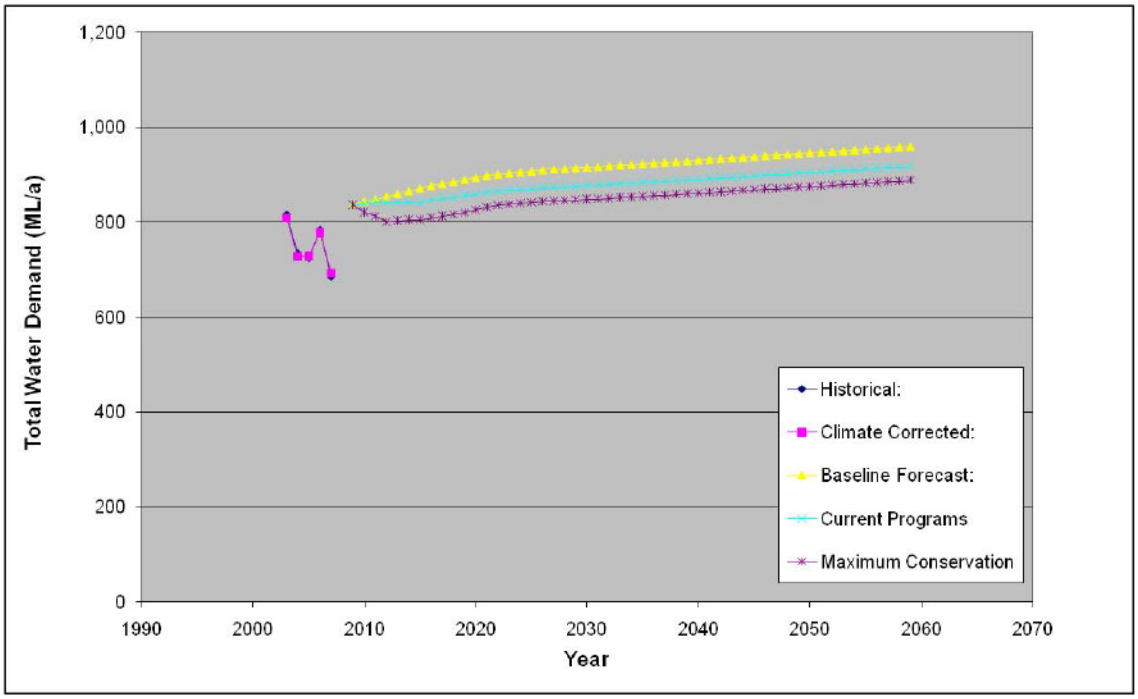

Figure B- 47: Oberon Annual Average Demand - Scenario Comparison (ML/a)

B.7.18 ORANGE

This study covered the areas of Orange and Clifton Grove serviced by the Orange Water Scheme. The population used for the study is the sum of the populations within these centres. The Local Government Area populations contain people not served by the scheme.

Table B- 82: Orange Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	36766
Total Accounts	959.18
Residential Accounts	0.00
Commercial Accounts	797
Industrial Accounts	0
Other Accounts	162

Table B- 83: Orange Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	843.4
Losses (% of production)	18.9%
Consumption (litres / account / day)	
Residential (existing)	784
Residential (new)	762
Commercial	2318
Industrial	0
Other	595

Table B- 84: Orange Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
EXISTING HOUSES		
Internal	413.80	52.8%
External	370.20	47.2%
NEW HOUSES		
Internal	392.30	51.4%
External	370.20	48.6%
Air conditioning demand (Litres / unit / day)		37.4

Table B- 85: Orange population and annual average demand forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	36,766	38,803	39,876	40,489	40,740	40,974	41,225	41,444	41,664	41,885	42,107
BASELINE DEMAND (ML)	5,837	6,180	6,391	6,547	6,657	6,773	6,896	7,018	7,143	7,270	7,399
CURRENT PROGRAMS (ML)	5,818	5,436	5,598	5,719	5,804	5,894	5,992	6,089	6,189	6,291	6,395
MAXIMUM CONSERVATION (ML)	5,818	5,369	5,493	5,588	5,659	5,736	5,821	5,906	5,994	6,083	6,174

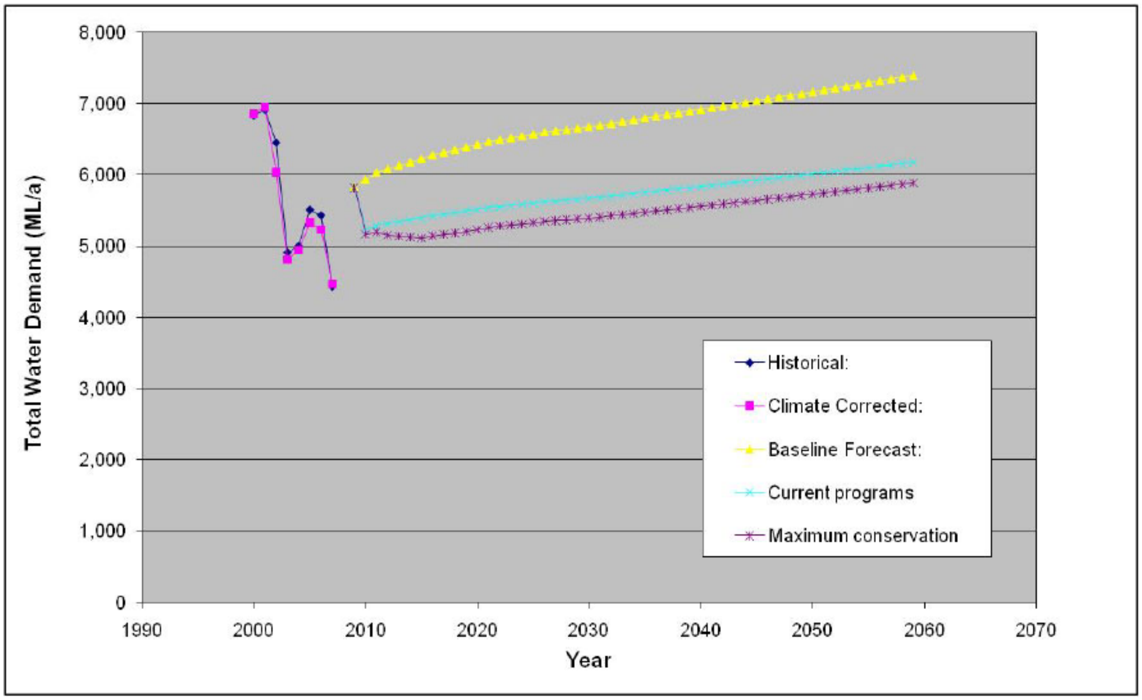

Figure B- 48: Orange Annual Average Demand - Scenario Comparison (ML/a)

B.7.19 PARKES

This study covered the areas of Parkes, Peak Hill and Alectown serviced by the Parkes Water Scheme. NorthParkes Mine is also included in this Study. The population used for the study is the sum of the populations within these centres. The Local Government Area populations contain people not served by the scheme.

Table B- 86: Parkes Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	11203
Total Accounts	4888
Residential Accounts	4635
Commercial Accounts	38
Industrial Accounts	80
Other Accounts	134
Northparkes Mine	1

Table B- 87: Parkes Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	818
Losses (% of production)	23.6
Consumption (litres / account / day)	
Residential (existing)	920
Residential (new)	898
Commercial	10960
Industrial	10960
Other	10960
Northparkes Mine	7,322,382

Table B- 88: Parkes Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
EXISTING HOUSES		
Internal	457.60	49.8%
External	462.00	50.2%
NEW HOUSES		
Internal	433.30	25.8%
External	1247.40	74.2%
Air conditioning demand (Litres / unit / day)		52.6

Table B- 89: Parkes population and annual average demand forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	11,203	11,647	11,963	12,250	12,513	12,773	13,029	13,283	13,532	13,778	14,021
BASELINE DEMAND (ML)	6,739	6,918	7,058	7,194	7,327	7,462	7,598	7,735	7,873	8,012	8,150
CURRENT PROGRAMS (ML)	6,731	6,537	6,583	6,690	6,805	6,923	7,042	7,163	7,284	7,405	7,527
MAXIMUM CONSERVATION (ML)	6,731	6,435	6,481	6,606	6,721	6,838	6,956	7,076	7,196	7,316	7,436

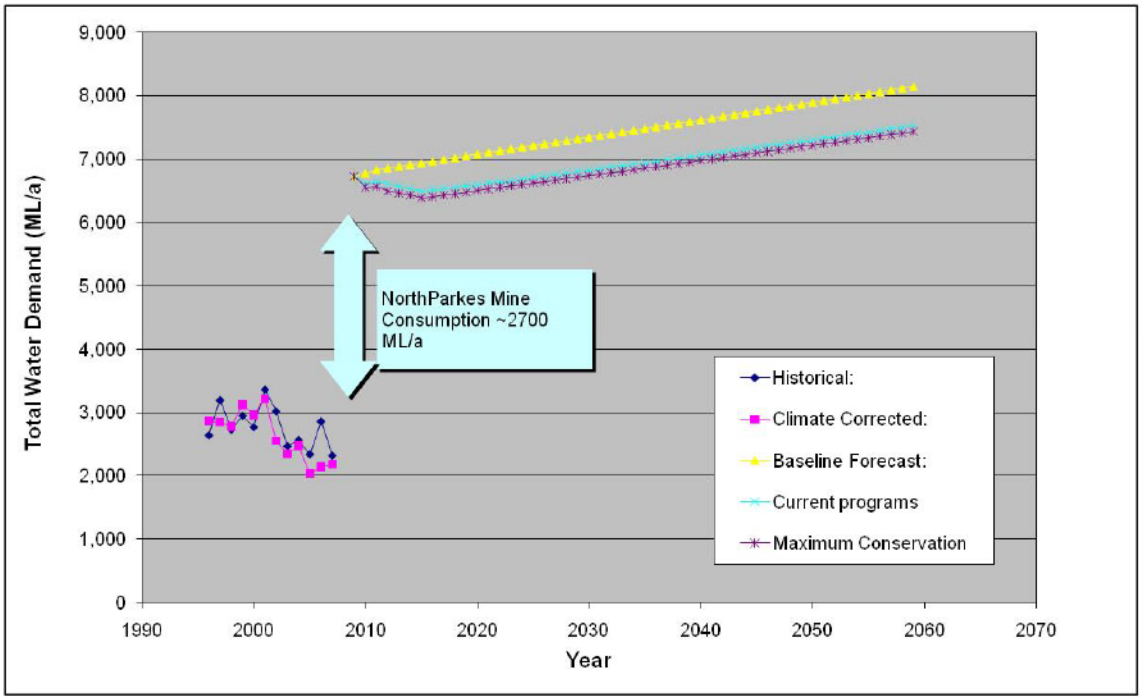

Figure B- 49: Parkes Annual Average Demand - Scenario Comparison (ML/a)

B.7.20 WELLINGTON / GEURIE

This study covered the areas of Wellington, Geurie and Nanima serviced by the Wellington Water Scheme. The population used for the study is the sum of the populations within these centres. The Local Government Area populations contain people not served by the scheme.

Table B- 90: Wellington / Geurie Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	5245
Total Accounts	3194
Residential Accounts	2905
Commercial Accounts	131
Industrial Accounts	20
Other Accounts	138

Table B- 91: Wellington / Geurie Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	699.7
Losses (% of production)	15%
Consumption (litres / account / day)	
Residential (existing)	863
Residential (new)	846
Commercial	2184
Industrial	2184
Other	2184

Table B- 92: Wellington / Geurie Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
EXISTING HOUSES		
Internal	344.60	39.9%
External	518.30	60.1%
NEW HOUSES		
Internal	327.30	38.7%
External	518.30	61.3%
Air conditioning demand (Litres / unit / day)	52.7	

Table B- 93: Wellington / Geurie Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	5,245	5,311	5,385	5,463	5,546	5,640	5,744	5,861	5,992	6,139	6,304
BASELINE DEMAND (ML)	1,348	1,389	1,434	1,482	1,534	1,590	1,651	1,716	1,786	1,862	1,946
CURRENT PROGRAMS (ML)	1,342	1,337	1,362	1,399	1,439	1,482	1,529	1,579	1,633	1,691	1,754
MAXIMUM CONSERVATION (ML)	1,342	1,302	1,327	1,368	1,407	1,450	1,497	1,546	1,599	1,656	1,718

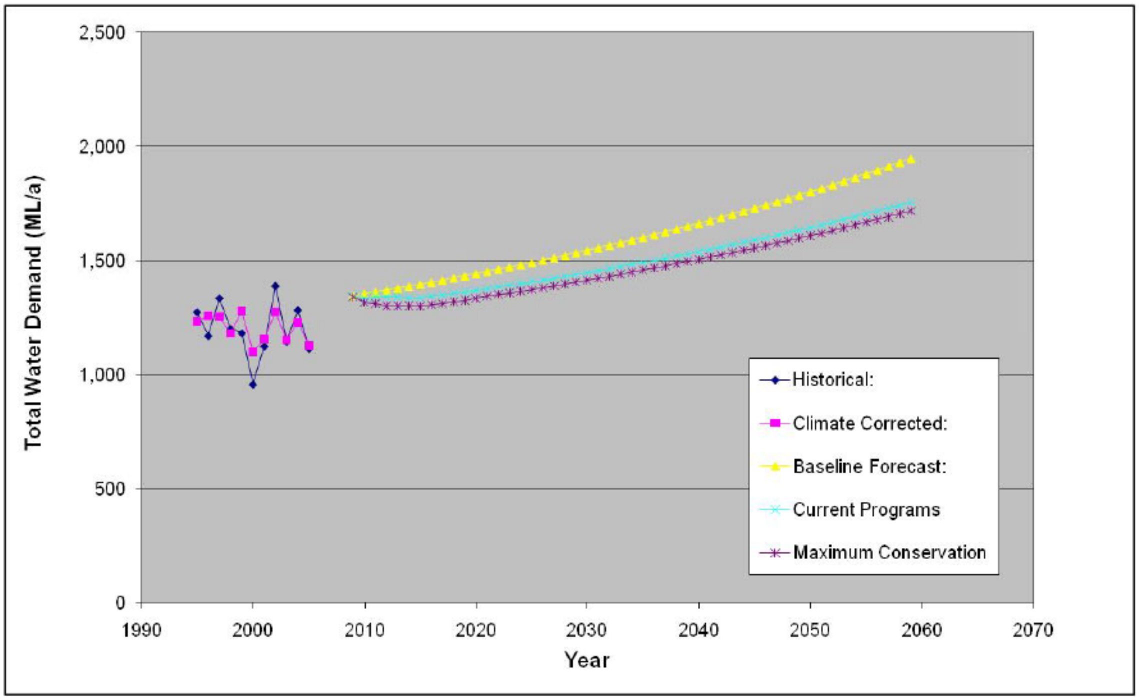

Figure B- 50: Wellington / Geurie Annual Average Demand - Scenario Comparison (ML/a)

B.7.21 YOUNG

This study covered the area of Young serviced by the Young Water Scheme. The population used for the study is the sum of the populations within the centre of Young. The Local Government Area population contains people not served by the scheme.

Table B- 94: Young Population and Account Numbers

PARAMETER	2009 INPUT/ ASSUMPTION
Population	7373
Total Accounts	4764
Residential Accounts	4333
Commercial Accounts	43
Industrial Accounts	154
Other Accounts	233

Table B- 95: Young Consumption Rates (2009)

PARAMETER	2009 INPUT/ ASSUMPTION
Production (litres / person / day)	600.8
Losses (% of production)	5.7%
Consumption (litres / account / day)	
Residential (existing)	527
Residential (new)	511
Commercial	12,570
Industrial	4,207
Other	3,021

Table B- 96: Young Residential Water use Breakdown

RESIDENTIAL USAGE	(L/ACC/DAY)	%
EXISTING HOUSES		
Internal	325.30	61.8%
External	201.50	38.2%
NEW HOUSES		
Internal	309.20	60.6%
External	201.50	39.4%
Air conditioning demand (Litres / unit / day)		42.4

Table B- 97: Young Population and Annual Average Demand Forecast

	2009	2014	2019	2024	2029	2034	2039	2044	2049	2054	2059
POPULATION	7,373	7,548	7,714	7,851	7,971	8,086	8,196	8,301	8,402	8,498	8,590
BASELINE DEMAND (ML)	1,618	1,662	1,706	1,748	1,789	1,831	1,873	1,915	1,957	1,998	2,039
CURRENT PROGRAMS (ML)	1,614	1,613	1,650	1,689	1,728	1,768	1,808	1,849	1,889	1,929	1,968
MAXIMUM CONSERVATION (ML)	1,614	1,546	1,584	1,635	1,674	1,714	1,754	1,794	1,834	1,873	1,913

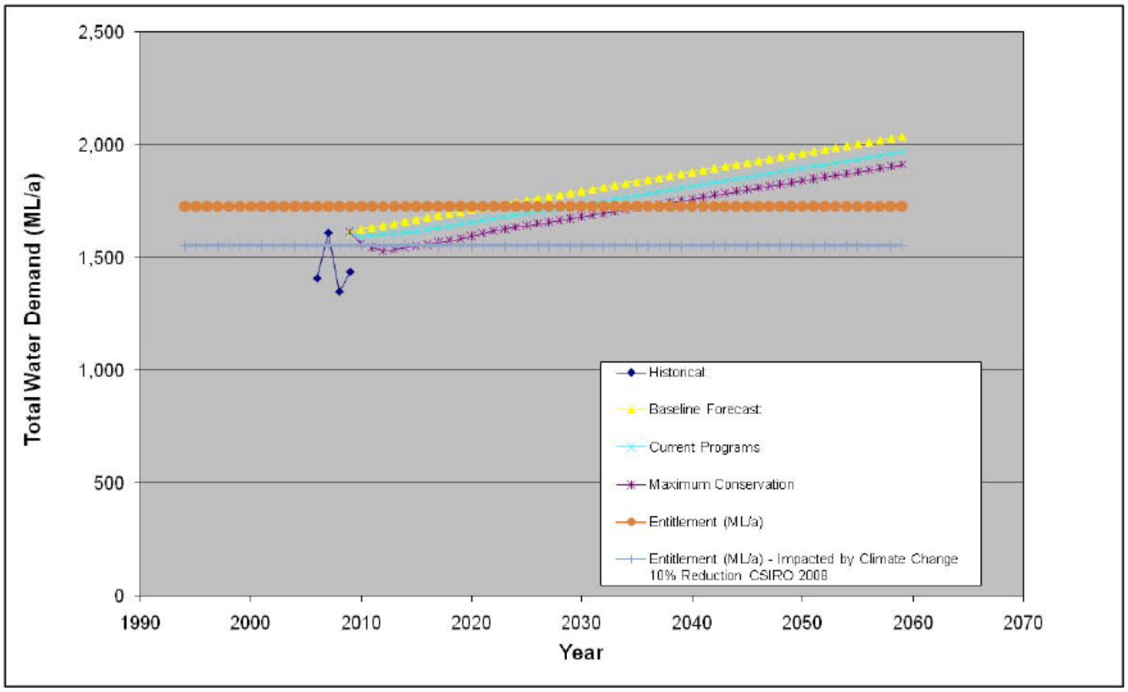

Figure B- 51: Young Annual Average Demand - Scenario Comparison (ML/a)