Report

Review of SA Water Supply Mix optimisation

3603-83

Prepared for
Essential Services Commission of South Australia

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Glossary

Term	Definition
ADP	Adelaide Desalination Plant
DEWNR	Department of Environment, Water and Natural Resources
ESCoSA	Essential Services Commission of South Australia
GIS	Geographical Information System
HOMA	Headworks Optimisation Model Adelaide
MAWSS	Metropolitan Adelaide Water Supply System
MLR	Mount Lofty Ranges
NPR	National Performance Report
RBP	Regulatory Business Proposal
SA Water	South Australian Water Corporation
SCADA	System Control and Data Acquisition
WTP	Water Treatment Plant

Executive Summary

Background

ESCoSA is currently undertaking a review of the revenue requirements of SA Water for the three year period beginning 1 July 2013 and it released a Draft Determination on 7 February 2013. The Final Determination is scheduled for completion in May 2013. An important component of SA Water's revenue requirements for the next three years is the operating expenditure required to source water. SA Water obtains water from four mains sources:

> Groundwater - which is typically an important source for small towns outside of Adelaide.

> The Adelaide Desalination Plant – which was recently completed and is able to supply up to half of Adelaide's drinking water at full capacity. The output from this source over the next three years will largely be determined by operating requirements to prove the plant. This is the most expensive source of water for the Adelaide region.

> Surface water collected in reservoirs in the Mount Lofty Ranges (MLR) – this is SA Water's cheapest source of water. However the volume available is not large, with storage equating to around 12 months' supply[1], and is dependent on rainfall.

> River Murray – water from this source makes up the balance of the water requirements for the Adelaide region. In drought years, the volume supplied from this source has been up to 90% of the total. Because of the costs of treating this water and pumping it from the River Murray to Adelaide, this source of water is more expensive than surface water collected in the MLR. A population of around 150,000 in townships along the river and in rural areas rely on the River Murray as their sole source of water.

Because of the significant differences in the variable costs of supplying water from each of the above sources, the Commission requires assurance that SA Water has made sound assumptions regarding the volume of water available from the MLR reservoirs over the next three years and the optimised portfolio of supplies available.

The work undertaken by ESCoSA to date to prepare its Draft Determination for SA Water's revenue requirements has identified a number of areas where modelling has been undertaken by SA Water to optimise its supply mix. The Commission is seeking independent and expert advice from a consultant regarding the technical robustness of modelling instruments used in performing the supply mix optimisation process of SA Water's water supply portfolio, as well as the appropriateness of the key assumptions underpinning it. The Commission believes updated modelling by SA Water should be undertaken with independent oversight to test the approach to, and the assumptions used, in the modelling. This is necessary because of the extent to which the mix of SA Water's supply sources can impact its operating expenditure.

The objectives of the project are to:

> Review the hydrological information and assumptions used by SA Water, including comparisons with any alternative hydrological information.

> Examine and review the technical nature of the models used in the optimisation of SA Water's water portfolio.

> Make recommendations on the reliability of the re-modelled results, in terms of the extent to which they reflect appropriate optimisation techniques and sound assumptions.

Methodology

This review has been based on informaiton provided by SA Water and DEWNR, face to face meetings with SA Water and DEWNR and analysis of data provided by SA Water. We have not independently verified the accuracy and completeness of the information provided to us or tested the coding and functionality of SA Water's HOMA model.

[1] *Water for Good, Government of South Australia, 2010. p27.*

Overview of HOMA model

HOMA is a linear programmed model which uses monthly time steps to simulate SA Water's bulk water supply network for the metropolitan Adelaide area and surrounding areas (referred to by SA Water as the Metropolitan Adelaide Water Supply System (MAWSS)). This supply network broadly consists of reservoirs that collect rainfall runoff from the Mount Lofty Ranges, pipelines and pumping stations from the River Murray, pipelines between reservoirs, water courses between reservoirs and water treatment plants.

For the purposes of bulk water distribution planning the HOMA model uses monthly time steps. Therefore, input data is typically entered as average monthly values. . The HOMA model is also used in an operational capacity to identify pipeline operation within the bulk water network. The results of the operational HOMA model are used by SA Water to generate weekly operational schedules.

The configuration of SA Water's bulk supply network within HOMA is represented schematically as shown in Figure 0-1. Note that the schematic includes some assets which are hypothetical only, such as hydroelectricity power plants. These assets have been included in the model to enable future simulation to include them if required.

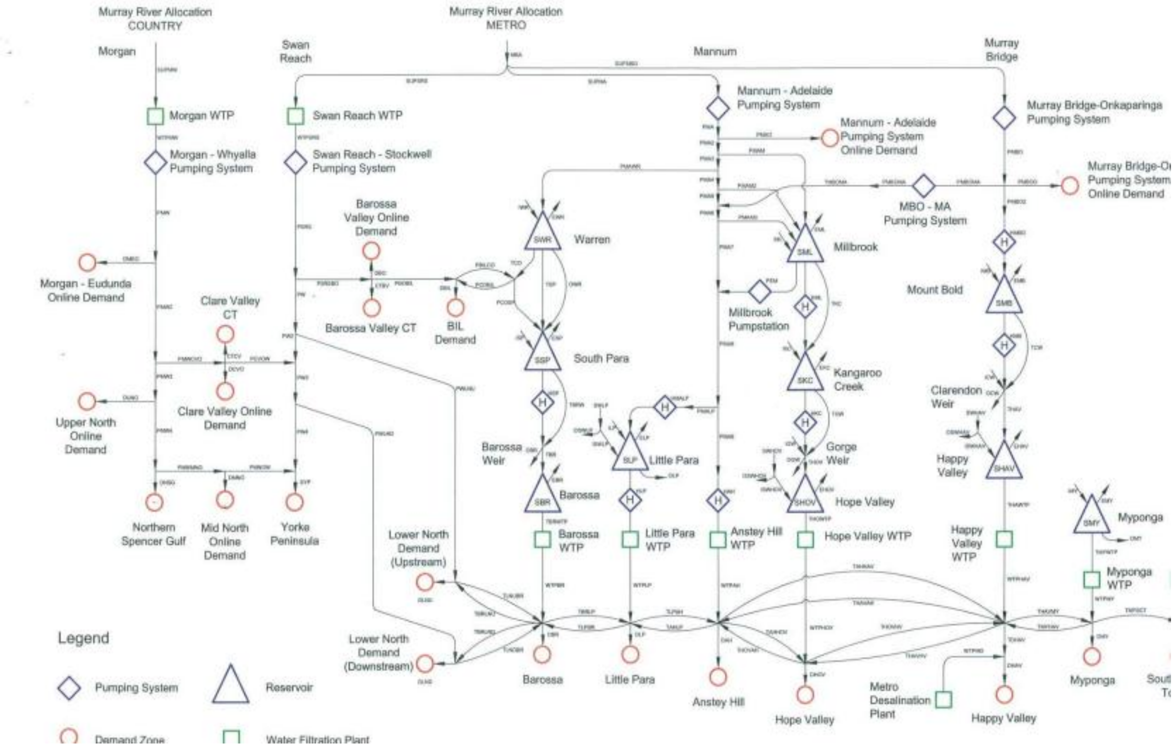

Figure 1 **Bulk water supply network schematic**

Conclusions

<u>Network configuration</u>

> We believe that HOMA model contains significant rigidities in how the bulk water supply network is represented. In particular, we conclude that:

- The model does not effectively take account for the increased flexibility in bulk water transfer provided to SA Water by the NSISP. This increased flexibility as described by SA Water is set out in Section 3.3.5.
- The manner in which WTP demand is largely based on historic records with coarse manual, monthly adjustments does not adequately reflect the operational flexibility available to SA Water in practice. The model does not appear to have the ability to select lower cost WTPs over higher cost WTPs.

- The constraint that the Anstey Hill WTP can only be supplied by the Mannum-Adelaide pipeline (from the River Murray) throughout the year with the exception of four months between February and May may overestimate the volume of water required from the River Murray.

> System flows do not account accurately for system losses in transmission mains and natural losses beyond evaporation. This can result in an underestimation of pumping volumes and an underestimation of the catchment inflows.

> The model works on average month inputs and monthly time steps. This does not correlate directly to system operation where operating parameters are typically changed much more frequently – hourly, daily or weekly. SA Water produces a weekly operating instructions report. This will lead to variation between actual operation (where parameters can be varied more regularly) and modelled results which is fixed for a month at a time.

MLR reservoir inflows

> We consider that it is reasonable that the median catchment inflow determined from SA Water's reservoir water balance from the last 10 years be used for the purposes of RBP modelling. This is because of the observed and documented differences between the inflows determined by SA Water's mass balance and those determined by the alternative approach of forecasting using a catchment hydrology model.

> We conclude that there are a number of sources of inaccuracy in SA Water's water mass balance. SA Water does not appear to know the materiality of these inaccuracies. Sources of inaccuracy include

- The reservoir storage and area curves used.
- No allowance for evaporation losses from the smaller reservoirs.
- No allowance for direct rainfall onto the reservoirs.
- No allowance for losses during transfers.

Costs

> It appears that fixed electricity costs for pumping are not included in HOMA. This constraint is likely to underestimate the cost of pumping water (from the River Murray) and therefore possibly 'overuses' this source in preference to other sources.

> The WTP operating costs in HOMA do not reflect actual costs and are very unlikely to reflect relative costs. However, as noted, the configuration of the model is such that it does not appear to have the ability to select lower cost WTPs over higher cost WTPs in any case.

HOMA results used in RBP

> In the 2013/14 year, the HOMA modelling results show that 4.1GL of water from the River Murray ends up being wasted to the system. Also, around 19.3GL of inflows are lost from the Gorge Weir that could have been used in place of water drawn from the River Murray

> The water supplied to the Barossa system from the River Murray appears to be in excess of that required given the level of inflows

> Analysis of the HOMA results used in the RBP show that when water from the ADP is available the reservoirs are allowed to spill in excess of the environmental flow requirements. While this may be due to timing of inflows, the volume (40GL/year) is significant and unlikely to reflect an optimised result.

On the basis of the above findings, we cannot conclude that the bulk water supply mix determined by SA Water for its RBP submission largely using its HOMA model represents an optimised result. Our major concerns are that:

> The configuration of the network in the model is rigid and does not reflect the flexibility of operation available to SA Water, in particular though:

- Operation of the NSISP.
- Assumption not to use Hope Valley WTP.

- Using least cost water treatment plants over higher cost plants.

> The monthly time steps in HOMA do not reflect the actual operational flexibility available to SA Water.

> The modelled results appear to include excessive spilling from reservoirs.

Recommendations

We recognise that there is a short term need for ESCoSA to assess matters relevant to SA Water's supply mix as represented in its RBP and a longer term need for SA Water to continually improve its supply mix optimisation. Therefore we make short term recommendations and recommendations for the medium term (nominally 6months – 2 years).

Short term recommendations

> Hope Valley WTP output for all years of the regulatory period to be at full capacity to make use of the new filters that have been installed. ADP water should be transferred to its next best use. If the process that SA Water uses to assign demand nodes to WTP cannot accurately determine the next best use of ADP water, then multiple scenarios should be run until the optimal solution found.

> Logical testing of the modelled outputs be performed so that unreasonable results such as River Murray water being spilled over weirs and lost to the system are avoided.

> Remodel the supply mix removing the assumption that Anstey Hill demand be supplied entirely by the Mannum – Adelaide pipeline for the majority of the year, and allow transfers from the Millbrook Reservoir. These results would be considered with reference to a risk management strategy for cryptosporidium that reflects the actual observed prevalence of cryptosporidium and appropriate operational strategies to address this problem. .

> Remodel the supply mix allowing increased transfers from the Happy Valley and Hope Valley WTPs to northern extremities of the water supply systems through the NSISP to minimise the volume of spill.

Medium term recommendations

> SA Water's reservoir mass balance model should be further refined, so that greater confidence in the average catchment inflows, and direct comparison with the catchment hydrology models can be achieved. We recommend that the following refinement to SA Water's reservoir mass balance be considered:

- Allowance for evaporation losses from the smaller reservoirs.
- Allowance for direct rainfall onto the reservoirs.
- Regular calibration checks of the rating curves or flowmeters used to determine transfer volumes and spills.
- Semi-regular reviews of the stage storage curves (the last review was conducted in 2008).
- Allowance for losses during transfers.
- Allowance for seepage from reservoirs. This can be determined through calibration of the reservoirs in WaterCress or use of typical seepage rates based on local soil conditions.
- Allowance for groundwater inflow if considered applicable.

> Ongoing efforts to reconcile SA Water's inflow estimates with those determined by DEWNR's hydrology models be made. This may include calibration of DEWNR's models using recent data.

> SA Water determine the level of accuracy (represented as a +/- accuracy band) associated with its reservoir inflow estimates.

Accurate and up to date costs for pumping and treatment be included in the model.

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1 Introduction

1.1 Background

SA Water is the dominant water supplier in South Australia, supplying drinking water to more than 95% of the State, including the Adelaide metropolitan area and surrounds. The Essential Services Commission of South Australia (ESCoSA) is the independent economic regulator of the water industry in South Australia and of SA Water.

ESCoSA is currently undertaking a review of the revenue requirements of SA Water for the three year period beginning 1 July 2013 and it released a Draft Determination on 7 February 2013. The Final Determination is scheduled for completion in May 2013. An important component of SA Water's revenue requirements for the next three years is the operating expenditure required to source water. SA Water obtains water from four mains sources:

> Groundwater - which is typically an important source for small towns outside of Adelaide.
> The Adelaide Desalination Plant – which was recently completed and is able to supply up to half of Adelaide's drinking water at full capacity. The output from this source over the next three years will largely be determined by operating requirements to prove the plant. This is the most expensive source of water for the Adelaide region.
> Surface water collected in reservoirs in the Mount Lofty Ranges (MLR) – this is SA Water's cheapest source of water. However the volume available is not large, with storage equating to around 12 months' supply[2], and is dependent on rainfall.
> River Murray – water from this source makes up the balance of the water requirements for the Adelaide region. In drought years, the volume supplied from this source has been up to 90% of the total. Because of the costs of treating this water and pumping it from the River Murray to Adelaide, this source of water is more expensive than surface water collected in the MLR. A population of around 150,000 in townships along the river and in rural areas rely on the River Murray as their sole source of water.

Because of the significant differences in the variable costs of supplying water from each of the above sources, the Commission requires assurance that SA Water has made sound assumptions regarding the volume of water available from the MLR reservoirs over the next three years and the optimised portfolio of supplies available.

1.2 Purpose of review

The work undertaken by ESCoSA to date to prepare its Draft Determination for SA Water's revenue requirements has identified a number of areas where modelling has been undertaken by SA Water to optimise its supply mix. The Commission is seeking independent and expert advice from a consultant regarding the technical robustness of modelling instruments used in performing the supply mix optimisation process of SA Water's water supply portfolio, as well as the appropriateness of the key assumptions underpinning it. The Commission believes updated modelling by SA Water should be undertaken with independent oversight to test the approach to, and the assumptions used, in the modelling. This is necessary because of the extent to which the mix of SA Water's supply sources can impact its operating expenditure.

The objectives of the project are to:

> Review the hydrological information and assumptions used by SA Water, including comparisons with any alternative hydrological information.
> Examine and review the technical nature of the models used in the optimisation of SA Water's water portfolio.
> Make recommendations on the reliability of the re-modelled results, in terms of the extent to which they reflect appropriate optimisation techniques and sound assumptions.

[2] *Water for Good, Government of South Australia, 2010. p27.*

1.3 Regulatory framework for water resources

The Department of Environment, Water and Natural Resources (DEWNR) is responsible for managing natural resources in South Australia, including water resources. The State is divided into eight geographical regions each of which has a Natural Resource Management Board which is responsible for preparing a Regional Natural Resource Management Plan as well as other management instruments. The Mount Lofty Ranges fall into the Adelaide and Mount Lofty Ranges management region. Natural Resource Management Boards have responsibility for preparing Water Allocation Plans for each region. The Adelaide and Mount Lofty Ranges Water Allocation Plan was released in draft form in 2010. The draft plan has been provided to the relevant Minister by the Board to consider for adoption. Under the Water Allocation Plan, SA Water is a designated existing user with entitlement to water allocations required to meet reasonable water supply to Adelaide and surrounding areas.

In 2009 the South Australian government released *Water for Good*, a long term strategy for securing the state's water supply until 2050. DEWNR is the department responsible for this document.

SA Water's abstraction of water from the River Murray is regulated by the State and Federal governments.

1.4 SA Water's approach to determining bulk water supply requirements and basis for this review

For its Regulatory Business Plan (RBP) submission to ESCoSA as part of the revenue requirements review, SA Water has determined its bulk water supply requirements through the following process[3]:

1. Determine drinking water demand for the three year period 2013/14 to 2015/16. SA Water appointed a consultant, ACIL Tasman, to undertake this work.
2. Convert drinking water demand to a bulk water requirement. This conversion was based on historical data and results in an estimate of bulk water supply requirements around 13% higher than drinking water demand mainly due to the losses that occur during the treatment and transfer of water.
3. Determine how to meet bulk water supply requirement from sources. For local systems, particularly in regional areas, there is only one source of supply. This is typically groundwater or the River Murray. Therefore, the most significant question addressed by SA Water was how to best meet the bulk water supply requirements of the Adelaide metropolitan area and surrounding areas, where alternative sources are available and cost optimisation is therefore a relevant issue to be considered. In determining the optimal mix of bulk water supplies for Adelaide and surrounds, SA Water:
   - Assumed that the output of the Adelaide Desalination Plant is fixed and based on the operating requirements for proving the plant. This assumption applies only for the first two years of the regulatory period. For the third year, SA Water has assumed that no water from the desalination plant will be required to meet bulk supply requirements.
   - Used its Headworks Optimisation Model (HOMA) to determine how the remaining bulk water supply needs would be met by the combination of supply from the Mount Lofty Ranges (lowest cost source) and the River Murray (higher cost source).

The important outputs from the modelling process are the volumes of water sourced from the River Murray and Mount Lofty Ranges respectively and the volume of water pumped through various pump stations to transfer water from the River Murray to SA Water's storage reservoirs in the Mount Lofty Ranges. The electricity costs associated with these pumping volumes were calculated by SA Water and form an important input into the operating expenditure forecasts included in its RBP as they typically comprise more than 40% of all electricity costs, excluding costs for the Adelaide Desalination Plant

[3] This process is detailed in the SA Water document "Summary – Input to OpEx Assumptions"

2 Methodology

To meet the objectives of this review, a number of complementary approaches were adopted which included review of documents, interviews with relevant SA Water and DEWNR staff and analysis of data. The following key activities were undertaken:

> Review of background information supplied by ESCoSA.

> Development and issue of a Review Plan to SA Water which set out interview themes and a request for information.

> Meeting with SA Water staff on Thursday 14 March 2013.

> Meeting with DEWNR staff on Friday 15 March 2013.

> Further requests for information of SA Water and DEWNR facilitated by ESCoSA.

> Preparation of a Draft Report that identifies our preliminary views on SA Water's approach to optimising its supply mix.

> Review of the draft report for factual accuracy by SA Water.

> Issue of a Final Report.

2.1 Basis for this review

SA Water's approach to determining the bulk water supply mix assumed for the RBP (detailed in Section 1.4) creates the bounds for this review. To meet the purpose of the review, which is to assess the technical robustness of modelling instruments used to determine this bulk water supply mix, we have:

> Not assessed the robustness of the demand forecasts used by SA Water as these have been subject to a separate review commissioned by ESCoSA.

> Accepted the conversion of water demand to bulk supply requirement using a factor of approximately 1.13 as reasonable[4].

> Accepted that the outputs of the Adelaide Desalination Plant are fixed during the proving period and as determined by the proving program of the Plant for the first two years of the regulatory period, and zero after that. This commissioning program has been considered as part of the review of SA Water's revenue requirements for the upcoming regulatory period and accepted by ESCoSA as prudent and efficient[5].

On the basis of the above, which takes as given a number of important factors, our review has focused particularly on SA Water's HOMA model and the outputs produced by it.

2.2 Limitations of this review

This review has been limited by the time available to review SA Water's approach and the documents made available to us. The discussion and findings in this report are based only on the documents provided to us and the verbal information provided by SA Water and DEWNR in our face to face meetings. We have not independently verified the accuracy and completeness of the information provided to us. We have also not tested the coding or build of the HOMA model to check that its functionality and simulation processes reflect the description provided to us by SA Water.

[4] The ACIL Tasman report into SA Water's demand forecasts for the RBP reports demand as 'billed water sales', That is, water delivered through residential and non-residential meters (and in some cases, estimated). Therefore, this estimate of bulk supply requirement includes losses in both the distribution network and the bulk supply network as well as during treatment. The best data set for benchmarking SA Water's assumptions should be provided in the *National Performance Report for Urban Water Utilities* produced by the National Water Commission. However, it is evident that different interpretations of the reporting indicators leads to reported data that is not directly comparable.

[5] *SA Water's Water and Sewerage Revenues 2013/14 – 2015/16, Draft Determination: Statement of reasons. Essential Services Commission of South Australia, February 2013. p80.*

3 Review of HOMA model

3.1 Overview of HOMA model

HOMA is a linear programmed model which uses monthly time steps to simulate SA Water's bulk water supply network for the metropolitan Adelaide area and surrounding areas (referred to by SA Water as the Metropolitan Adelaide Water Supply System (MAWSS)). This supply network broadly consists of reservoirs that collect rainfall runoff from the Mount Lofty Ranges, pipelines and pumping stations from the River Murray, pipelines between reservoirs, water courses between reservoirs and water treatment plants.

For the purposes of bulk water distribution planning the HOMA model uses monthly time steps. Therefore, input data is typically entered as average monthly values. . The HOMA model is also used in an operational capacity to identify pipeline operation within the bulk water network. The results of the operational HOMA model are used by SA Water to generate weekly operational schedules.

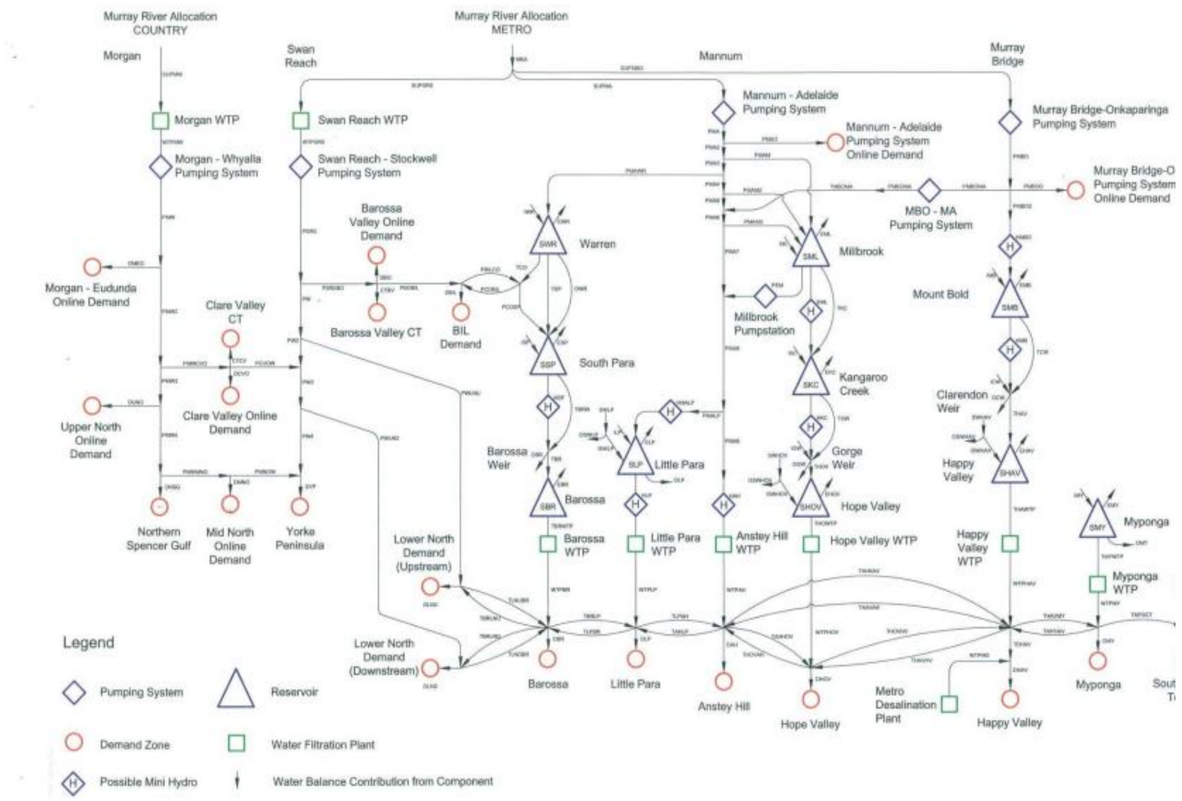
3.2 Model inputs

3.2.1 Overview

The following sections described important inputs into the HOMA model. Not all inputs are described, only those relevant to this review. More description of the model inputs is provided in the *HOMA Modelling Package – Model Documentation*[6] report.

3.2.2 Network configuration

The configuration of SA Water's bulk supply network for the MAWSS is represented schematically within HOMA as shown in Figure 3-1. Note that the schematic includes some assets which are hypothetical only, such as hydroelectricity power plants. These assets have been included in the model to enable future simulation to include them if required.



6 HOMA Modelling Package – Model Documentation. Tonkin consulting, 2006.

Figure 3-1 MAWSS bulk water supply network schematic

Source: HOMA^{XP} Modelling Package – Model Documentation, Tonkin Consulting 2006.

The components included in the network configuration are:

> Pumps.

> Reservoirs.

> Water treatment plants.

> Demand nodes.

> Linkages between pumps, reservoirs and water treatment plants.

3.2.3 Demand

To inform its RBP submission, SA Water engaged a consultant to forecast demand over the three year regulatory period (and beyond). Demand was determined by SA Water's consultant as billed water volumes and converted by SA Water into bulk water requirements at its water treatment plants (WTPs) accounting for both the supply to country areas directly off the bulk water mains and the metropolitan Adelaide demand. Table 3-1 summarises the billed water demand determined by SA Water's consultant and this demand converted to bulk water demand.

Table 3-1 Billed water demand and bulk water demand assumptions for RBP period

	2013/14	2014/15	2015/16
Billed water demand (GL/year)	179	181	184
Bulk Water demand (GL/year)	203	206	209

ESCoSA commissioned its own review of SA Water's future demands. We have not commented on this review.

3.2.4 Distribution of demand across treatment plants

SA Water utilises a desktop spreadsheet model to distribute network demands across each of its six WTPs in the MAWSS. It can be seen in Figure 3-1 that for each water treatment plant there is an associated demand node.

SA Water advised that the excel spreadsheet *RFI0139 Metro Water Distribution Model FINAL 19_6_12 (for NSISP team-ADP figures for April)_used for ESCOSA Budget.xlsx* is used to determine the demands from each WTP based on the determined demand. This spreadsheet has a documented monthly schedule of WTP operation to the major metro demand zones. However, it appears that only the WTP capacity and network capacity are utilised as the inputs for this system configuration. The stated objective of this spreadsheet is to minimise transfers across the NSISP.

The level of demand for drinking water, and converted to bulk water demand as determined by SA Water, is converted to monthly demands, based on historical monthly averages for each WTP zone. SA Water advised each demand node is also capable of being serviced via other WTPs besides the WTP assigned to the demand node. This is performed by manually assigning to each demand node a proportion of demand to be supplied by each treatment plant, as shown in Figure 3-2. Where the grid square is coloured green, this means that the demand node (listed in the first two columns) may be supplied by the corresponding treatment plants in the first row of the matrix. Conversely, a grey coloured grid square means that the demand node cannot be supplied by the corresponding water treatment plant.

Supply WTP (Please just PASTE VALUES over top)						
Original Name	*Name Used*	Barossa	Little Para	Anstey Hill	Hope Valley	Happy Valley/ADP
D-Bar	BR	1.				
D-BS	BRS	1.				
D-LP	LP		1.			
AHN	AHN			1.		
AHS	AHS			1.		
170N	170N			0.3		0.7
170C	170C					1.
103N	103N					1.
51N	51N			0.3		0.7
170S	170S					1.
103C	103C					1.
103S	103S					1.
51S	51S					1.
HaVs	HAVS					1.
103L	103L	0.	0.	0.	0.	1.

Figure 3-2 Data entry tool to assign demand to WTPs

The assignation of demand to WTPs is reflected in the monthly HOMAxp model runs. Figure 3-3 illustrates graphically the WTP demand distribution model utilised by SA Water. Within the HOMAxp model should a WTP be out of production the model is updated to either transfer between zones (where possible) or via the reassigning of demand from one WTP zone to another zone.

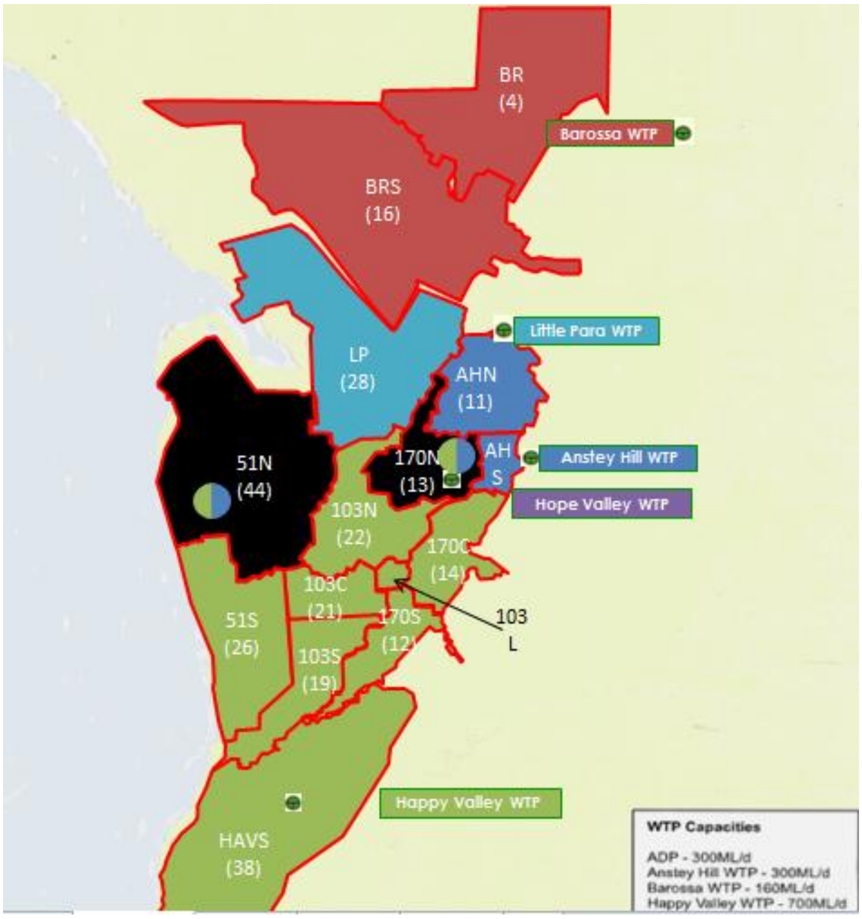


Figure 3-3 HOMAxp WTP Demand Zones

3.2.5 Inflows to MLR reservoirs

The inflows from the MLR used in the HOMA analysis for the RBP have been based on the median inflow of the last 10 years (2002/03 to 2011/12), which was calculated using a reservoir mass balance. The resultant median value was 113 GL/year.

This method of calculating inflows into the reservoirs is different to that used by DEWNR in its catchment hydrology models. The SA Water reservoir mass balance calculates catchment inflows based on the following equation:

$$\begin{aligned} &Catchment\ Inflow \\ &\quad = \Delta Storage\ Volume + Evaporation - Murray\ River\ Transfers \\ &\quad + Environmental\ Flow\ Releases + WTP\ offtakes + Spills \end{aligned}$$

Transfers between the storages are also accounted for.

This method of calculating inflows has inherent limitations, as the accuracy of the inflow estimate is based on several variables. In particular, the volume and area (which is used to determine evaporation) of each reservoir is based on 'rating curves' that specify a relationship between the depth of the reservoir, as measured at a gauging board, and the volume and area. The accuracy of these rating curves affects the level of confidence in each variable. Also, the relationship between reservoir depth and storage and area will change over time in particular as sediment is deposited within the reservoir. This means that the rating curves need to be calibrated from time to time. There are also a number of variables which appear to have not been included in the reservoir mass balance. These variables include seepage losses from the reservoirs, groundwater inflow into the reservoirs, rainfall directly onto the storages, evaporation losses from the smaller reservoirs and seepage losses during transfers. From an operational viewpoint, not accounting for these variables may be justifiable, as they are also not included in HOMA and therefore the source data has a consistent basis.

As noted in internal DEWNR draft reviews[7] of the MLR catchment hydrology models, there are several periods of discrepancy, both positive and negative, between the catchment inflow estimates calculated using the reservoir mass balance method and the catchment hydrology models. Given the complexity of the MLR systems, the various changes that have historically occurred in the catchment and the lack of quality data, the process of comparing the two methods was difficult. However, since 2000 the catchment hydrology models used by DEWNR have consistently overestimated the inflows when compared to the results of the reservoir mass balance as well as the gauged stream flows.

The catchment hydrology models used by DEWNR are WaterCress (referred to as WC1) and the Australian Water Balance Model (AWBM). These models use daily rainfall and evaporation patterns over a catchment area as well as assumed catchment parameters to create inflows. These inflows are then used in the WaterCress program, which takes into account pumped inflows, sub-catchment inflows, farm dam diversions and the impact of storages (where appropriate) to calibrate to stream gauges. The catchment parameters are modified until an acceptable level of calibration is achieved for a period of 20 to 30 years. The models can then use historical or statistically estimated rainfall and evaporation data to get an estimate of the inflows. These models were last calibrated by DEWNR between 2003 and 2006[8].

The accuracy of the catchment hydrology models is dependent on the quality and quantity of rainfall, evaporation and stream gauge data, and the accuracy of assumptions about farm dam diversion rates, pumping volumes, catchment characteristics and storages. The catchment hydrology models and WaterCress are used to define the flows in the stream upstream of the reservoir, whereas the "catchment inflow" used in the reservoir mass balances is equivalent to a point directly downstream of the reservoir. The two methods of calculating inflows are therefore difficult to directly compare, unless evaporation, seepage

[7] *Extension of Surface Hydrologic Modelling for the Catchments of SA Water's Reservoirs in the Western Mount Lofty Ranges Prescribed Water Resource Area*. Richard Clark and Associates, 2011. Draft Report. Stage 2 Report September 2011, Addendum November 2011 and both revised August 2012. Referred to as Clark 2011.
[8] Personal communication, *Mark Alcorn, DEWNR.*

and other variables can be accurately accounted for. However, the catchment hydrology models can be directly compared to the gauged stream flows, which have also shown a significant decrease since 2000.

The average rainfall between 2000 and 2010 was not significantly different to the previous 20 year period despite the drought period between 2006 and 2008 (Clark, 2011).

The internal DEWNR review as documented in Clark 2011 has suggested three reasons for the flow discrepancy since 2000:

> Errors in the calculations or reservoir inflows, in the estimation of gauged flows or the estimation of catchment rainfall or evaporation.

> An inability of the models to cope with changed rainfall or evaporation sequences or patterns.

> Changing catchment processes/activities over the past 11 years, co-incidental with, but not necessarily related to the spread of farm dams. These may include a combination of changing crops, improved soil moisture retention, direct seeding, and means for reducing erosion, improving water quality and agricultural activity.

The internal review as documented in Clark 2011 suggests that the third cause is most likely the reason for the recent reduction in flow volumes.

Based on the observed recent change in rainfall runoff patterns, which are key inputs into catchment hydrology models for determining reservoir inflows, that has been documented and investigated (but not resolved), we consider that it is reasonable that the median catchment inflow as estimated by SA Water's water balance from the last 10 years be used for the purposes of RBP modelling rather than inflows determined by catchment hydrology models. We also consider that it is reasonable to use the reservoir mass balance method to calculate these inflows, as this will best correlate with the assumptions and constraints of the HOMA modelling.

Further investigation will be required to determine the reasons behind the observed change in rainfall-runoff patterns. Re-calibration of the catchment-hydrology models using recent rainfall data would be required to better compare inflow forecasts from catchment hydrology models with the inflows recorded by SA Water.

We recommend that SA Water's reservoir mass balance model should be further refined, so that greater confidence in the average catchment inflows, and direct comparison with the catchment hydrology models can be achieved. We recommend that the following refinement to SA Water's reservoir mass balance be considered:

> Allowance for evaporation losses from the smaller reservoirs.

> Allowance for direct rainfall onto the reservoirs.

> Regular calibration checks of the rating curves or flowmeters used to determine transfer volumes and spills.

> Semi-regular reviews of the rating curves for reservoirs which relate measured depth to volume and area (the last review was conducted in 2008).

> Allowance for losses during transfers.

> Allowance for seepage from reservoirs. This can be determined through calibration of the reservoirs in WaterCress or use of typical seepage rates based on local soil conditions.

> Allowance for groundwater inflow if considered applicable.

We also recommend that the inflow estimates determined by SA Water's mass balance be reconciled against estimates determined by DEWNR's catchment hydrology models. We appreciate that this work has commenced but consider that there is significant benefit in advancing this work both to SA Water and DEWNR. This will also allow the catchment hydrology model inflows to be used in future RBP assessments alongside water balance estimates. The advantages of this will be:

> A longer rainfall period will be able to be used to calculate catchment inflows. A period of 30 years would ideally be used to calculate median inflows.

> The catchment hydrology and WaterCress models can account for changes in land use, rainfall etc. The implications of these changes can then be determined in HOMA.

We recommend that future assessments of reservoir inflows should also look at the sensitivity of RBP estimates to various scenarios, in particular wet or dry years. The definition of a wet and dry year may be determined with reference to different percentiles of long term rainfall records.

3.2.6 Costs

The HOMA model includes the following cost information:

> Pumping system cost curves

> Water treatment plant operating costs

> Penalty costs for spilling from a reservoir or not meeting the ‘target level’.

> Other cost functions which are either not used or not relevant for this analysis (e.g. cost of water harvesting, cost of stormwater reuse, etc.)

An example pumping costs curve is shown in Figure 3-4.

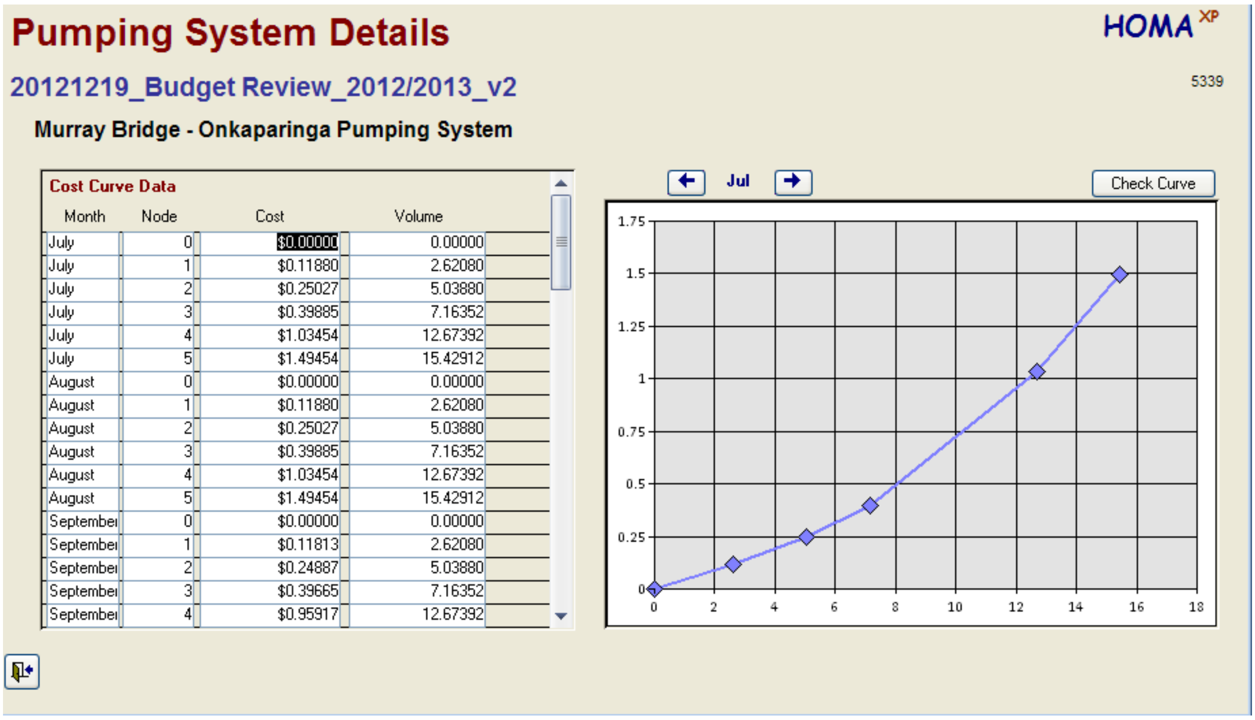


Figure 3-4 HOMAxp Pump Cost Curve (May, June July August)

We understand that SA Water’s electricity model assumes charges for its major pump stations are a flat rate per volume of energy consumed ($/MWh). That is, there is no on/off peak tariff or network access charge. This is not the reality in that SA Water’s contract for electricity supply contains a range of varying tariffs for general/economy rates, summer/winter/mild seasons, business day/non business day and three hour blocks. Based on historical and expected patterns of electricity use at these sites, SA Water weights each of these tariffs to arrive at an estimated flat rate.

A flat rate for variable energy use would result in a linear cost function if there was also a linear relationship between the volume transferred and energy usage. However, generally, increased pumping to transfer increased volumes will lead to pumps having to be operated outside of their most efficient range and increased friction losses in pipelines and therefore increasing unit costs per volume transferred. The shape of the cost curve shown is consistent with this relationship.

However, the cost curve crosses the y-axis at zero unit cost suggesting that there is no charge when no water is pumped. This does not reflect the reality of SA Water's electricity charges which include in reality fixed charges regardless of the volumes pumped. Inclusion of these fixed charges would logically lead to the cost curve crossing the y-axis at a positive number.

Therefore, while the shape of the cost function appears to reflect the operating environment, it appears that the cost curve does not reflect the fixed charges SA Water has to pay. As a result, the model is likely to underestimate the cost of pumping water (from the River Murray) and therefore possibly 'overuses' this source in preference to other sources. This 'overuse' would logically occur within the model until the marginal cost of supply from the River Murray matches the marginal cost of supply from the MLR reservoirs.

Figure 3-5 shows the cost function for an example WTP. The cost function is a flat rate per volume of water processed throughout the year.

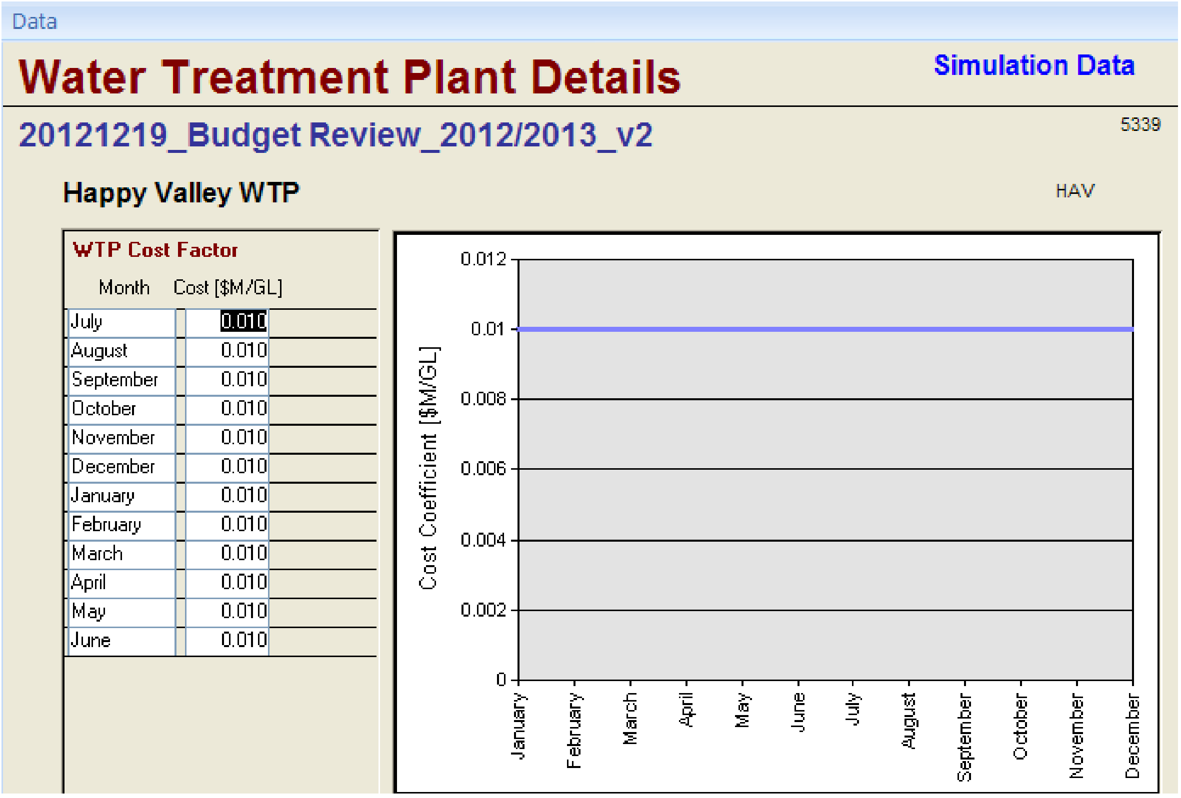


Figure 3-5 HOMAxp WTP Cost

SA Water provided to us the unit costs of its water treatment plants and these are summarised in Table 3-2. Note that the costs include direct costs only so are exclusive of indirect costs such as overheads.

Table 3-2 Water treatment plant costs

	Cost ($/ML)
Happy Valley	[redacted]
Barossa	[redacted]
Anstey Hill	[redacted]
Hope Valley	[redacted]
Little Para	[redacted]
Myponga	[redacted]

Comparing Table 3-2 and Figure 3-5, it is clear that the WTP costs used in HOMA are not actual costs as there is approximately a factor of ten difference between the costs of each [redacted] which cannot be explained by the absence of indirect costs. It is noted in the HOMA model documentation and by SA Water that it is sufficient that the costs functions (for all costs, e.g. pumping, WTPs, etc.) in HOMA are correct relative to each other rather than being absolutely correct. This is true, but there is no indication in the evidence that we have seen that the cost functions are relatively correct given that they are not absolutely correct either.

However, it appears that the cost function for WTPs included in HOMA play little or no role in determining the optimised bulk water supply mix. This is because of the way in which the model is configured with a WTP given a fixed demand to meet each month as described in Section 3.2.4. Therefore, there is no ability for HOMA to choose a lower cost water treatment plant over a higher cost water treatment plant to result in a lower total cost of supply. Network constraints and proximity will mean that there is a limit to the extent to which each water treatment plant can supply the ‘designated’ supply region of another treatment plant. Nevertheless, we consider this rigid assumption a significant limitation on the ability of HOMA to determine a least cost mix of supply sources. This is reinforced by the recent commissioning of the North-South Interconnection System which provides greater flexibility for SA Water to transfer water between supply zones.

3.3 Operating constraints

3.3.1 WTP Operating Assumptions

SA Water accounts for the operating capacity and availability within the HOMAxp Model. Both minimum and maximum production rates are accounted for and factored into the HOMAxp modelling process. In addition SA Water account for known WTP shutdowns and capital works improvements that affect the operational capacities of their WTPs. Use of the HOMA model and the Metropolitan Adelaide Desalination Plant HOMAXP Modelling Investigation (Tonkin, 2008) identify strategic periods of the year during which the existing WTPs can be operated to improve network operation whilst incorporating the contractual flows from the ADP.

SA Water identified that the WTP service zones are managed month to month based on operational constraints. The key operational constraints identified are:

> WTP Minimum Capacity.
> WTP Maximum Capacity.
> Trunk transfer capacity with the pipelines.
> WTP operational capacity (e.g. 100%, 60% or offline).

The operation of the WTPs is a key factor in the HOMA Model. For example the Anstey Hill WTP has been assumed in HOMA to be supplied by the Mannum-Adelaide pipeline throughout the year with the exception of four months between February and May. The Anstey Hill WTP can also be supplied by the Millbrook Reservoir. The justification for this operating procedure was the cryptosporidium risk historically observed in this reservoir during winter months. As such the method of delivery of bulk water to the WTPs is a critical assumption within the HOMA model.

3.3.2 Environmental flows

The trial environmental flows used in the HOMA modelling for the RBP period are:

> 2.238 GL/year discharged from the South Parra/ Barossa system at the Barossa Diversion Weir.
> 0.891 GL/year discharged from the River Torrens system at the Gorge Weir (4.113 GL/year released at Gumeracha Weir will be intercepted by downstream reservoirs).
> 9.240 GL/year discharged from the Onkaparinga System at the Clarendon Weir.

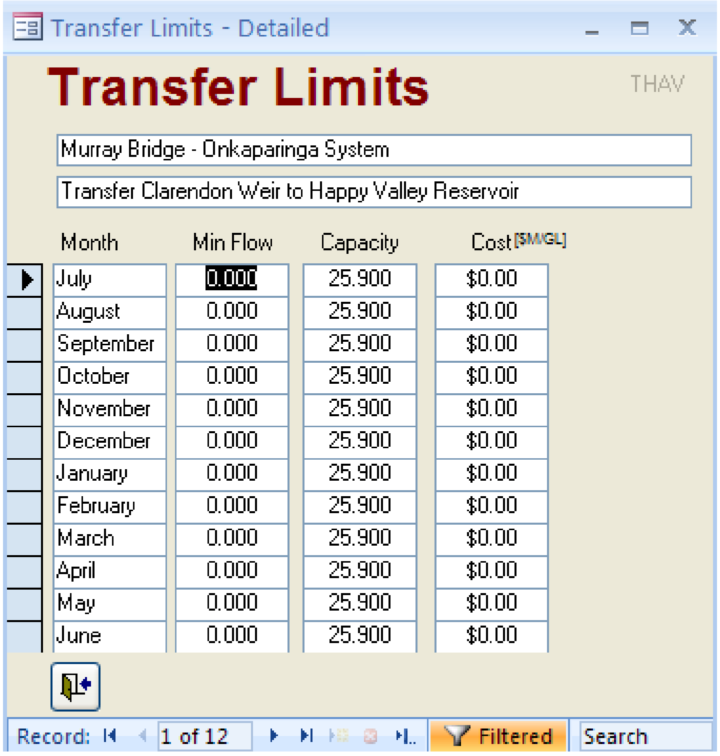
The total environmental flow releases modelled are 12.349 GL/year.

3.3.3 Reservoir target levels

Each reservoir included in the model has a target storage level. This target level mostly reflects a desired standard for reliability of supply. ‘Penalty’ costs are included in the model so that these target levels can be met. The penalty costs are artificial costs included within HOMA’s optimisation functions so that the objective of not spilling from the reservoirs is accounted for.

3.3.4 Pipeline capacity

SA Water specifies a minimum and maximum capacity of each pipeline within HOMA. The minimum capacity identified for each pipeline takes into account flows required to service either a direct demand from a pipeline and/or the volume required to prevent undesirable water quality. It should be noted that the HOMA model does not materially account for transmission losses within the bulk water supply network. Transfer capacities are generated based on the hydraulic capacity of the pipeline. However, they are also related to the capacity (and demands) at each WTP such that large bulk transfers over and above the capacity of the WTP are not achieved. Figure 3-1 represents an example of the pipe capacity data within the HOMAxp model.


Transfer Limits - Detailed

Transfer Limits

THAV

Murray Bridge - Onkaparinga System

Transfer Clarendon Weir to Happy Valley Reservoir

Month	Min Flow	Capacity	Cost [$M/GL]
July	0.000	25.900	$0.00
August	0.000	25.900	$0.00
September	0.000	25.900	$0.00
October	0.000	25.900	$0.00
November	0.000	25.900	$0.00
December	0.000	25.900	$0.00
January	0.000	25.900	$0.00
February	0.000	25.900	$0.00
March	0.000	25.900	$0.00
April	0.000	25.900	$0.00
May	0.000	25.900	$0.00
June	0.000	25.900	$0.00

Record: 1 of 12 Filtered Search

Figure 3-1 HOMAxp Pipeline Capacity Data

3.3.5 North-South Interconnection System (NSISP)

The NSISP is now operational. The purpose of the NSISP is to link the distribution networks to allow greater flexibility in the water supply system. The stated capabilities of the NSISP include the ability to[9]:

> Transfer water from Happy Valley WTP and the ADP to the northern extremities of the metropolitan water system (into the Hope Valley, Anstey Hill, Little Para and Barossa WTP supply areas).

> Transfer water from Anstey Hill WTP further north into the Little Para and Barossa WTP zones.

> Expand the western suburbs distribution area for Hope Valley WTP and Anstey Hill WTP.

> Shut down Hope Valley and Little Para WTPs for longer periods of time during winter, autumn and spring.

> Maximise production volumes from the lowest cost WTPs.

> Enable use of the best raw water source given water quality and water availability constraints.

[9] *Input to OpEx Assumptions, SA Water, p9.*

> Exercise flexibility in choice of WTPs enabling increased use of low cost plants.

The configuration of the HOMA model detailed in Section 3.2.2 and the fitting of demand to WTPs outlined in Section 3.2.4 means that greater flexibility for bulk water distribution is available to SA Water than in previous years. However, we cannot see that this greater flexibility is reflected in HOMA except through the coarse means of varying the monthly assumed proportion of water supplied to water zones from each treatment plant.

3.4 Model outputs

The outputs from model simulations are five excel files containing:

> Pumping volumes.

> Evaporation from storages.

> Reservoir levels at the end of each monthly time step.

> WTP input.

> Transfers between nodes.

3.5 Relationship of HOMA to other system modelling tools

SA Water identified key relationships between the HOMA model and other in-house models and planning tools used for the planning and operation of the bulk water supply network. The HOMA model is reliant on the use of inputs from a variety of sources, with the outputs of HOMA being integral as inputs for others.

Key planning tools used as inputs to the HOMA model include:

> WTP service demand spreadsheet.

> Inflow estimates from SA Water water balance (as discussed in Section 3.2.5).

Results from the HOMA model are imported as inputs into:

> Pump scheduler.

SA Water also operates network reticulation models in the WaterGEMS software platform. SA Water advised that WaterGEMS model has limited interface with the HOMA model, and is used for of verification of other modelling results and WTP operation.

In addition to the tools and models utilised by SA Water with the HOMA model, we have identified that SA Water has developed in conjunction with a specialist firm in this area, Optimatics, a tool that will be used for optimising operation of the bulk water supply network in future. SA Water has informed us that when this tool is functional that HOMA will only be used for long term planning (10-100 years). However, as HOMA has been used for the basis of the bulk supply optimisation presented in SA Water’s RBP, we have not considered this tool at this point in time.

4 Results of HOMA used in RBP

For the purposes of RBP planning, HOMA was run for the years 2013/14, 2014/15 and 2015/16, using the median inflow to MLR reservoirs totaling 113 GL/year, the defined ADP supply volumes and the constraints and assumptions outlined in Section 4. The predicted sources of water during these years are shown in Table 4-1.

Table 4-1 Source Water RBP Estimates

	2013/14	2014/15	2015/16
Bulk Water demand (GL/year)	203	206	209
Source Water			
River Murray (GL/year)	81	87	105
MLR Inflows (GL/year)	45	72	92
ADP Inflows (GL/year)	65	35	0
Groundwater (GL/year)	12	12	12

From Table 4-1 it is clear that when ADP inflows are available less water from the MLR is used. However, the proportion of River Murray water used is not as significantly reduced. For example, in 2013/14, water sourced from the River Murray is 24 GL less than in 2015/16 despite there being 65 GL more water available from the ADP in 2013/14 compared to 2015/16. This suggests that SA Water's modelling leads to ADP water displacing MLR reservoir water in the forecast supply mix rather than River Murray water, despite MLR reservoir water being a significantly lower cost source than River Murray water. SA Water has offered many reasons for why this is the case, including:

> Seasonal variations – the fact that reservoir inflows are greatest in winter but demand is greater in summer.

> The need to maintain supply to customers whose sole source is the River Murray.

> Operational constraints such as:

  - Cryptosporidium risk at the Hope Valley WTP.
  - Maintaining water quality in bulk transfer mains.

We have found that SA Water has in few instances quantified the impact of each of these factors on the supply mix, relying instead on the results of the HOMA model as an accurate reflection of the operation of its bulk supply network. We have been surprised at the degree to which SA Water appears to unquestioningly accept the HOMA model outputs. All modelling, by its very nature, has inherent inaccuracies and misrepresentations of the actual circumstance being modelled. We would expect SA Water to have been able to articulate these limitations to us. The only critical analysis we have been provided with is a historical comparison of actual pumped volumes with volumes predicted by HOMA for the period 1990/91 to 1999/00. For this period, SA Water found that HOMA underestimated the actual pumping required from the River Murray by an average of 7.9GL/annum.

Given the limited information provided to us by SA Water on the efficacy of HOMA, we have sought to test its reliability through inspection of the outputs modelled for the RBP. Given the limited time available for this review and the significant amount of output data produced by HOMA, we have focused on two areas:

1. The water drawn from the River Murray for the Mannum-Adelaide in the 2013/14 year.
2. Spill volumes lost to the MLR reservoir system.

4.1 Analysis of Mannum-Adelaide system in 2013/14

The Mannum to Adelaide pumping system consists of a pipeline that can supply water to the Barossa, Anstey Hill, Little Para and Hope Valley water treatment plants. Each treatment plant can also be supplied from inflows to reservoirs as follows:

> Barossa WTP: Warren and South Para reservoirs.

> Anstey Hill: Millbrook.

> Hope Valley: Millbrook and Kangaroo Creek.

We performed a water balance around this system for the 2013/14 year and identified that a total of 24.6 GL is drawn from the Murray in this year. The end use of this water is summarised in Table 4-2.

Table 4-2 End use of River Murray Water in Mannum-Adelaide system

	Volume (GL)
Spilled over the Gorge Weir	4.1
Treated at Anstey Hill	12.1
Transferred to Barossa System	8.4
Total	**24.6**

We make the following observations about the water balance for this system in 2013/14:

> The 4.1GL sourced from the River Murray that is spilled over the Gorge Weir and lost to the system is both far in excess of SA Water's trial environmental flow (0.89GL) and under the modelled scenario could have been supplied from reservoir inflows rather than the River Murray (also see discussion following in Section 4.2). Therefore, this 4.1GL appears to be an unnecessary waste of water.

> The Hope Valley WTP does not operate at all during the 2013/14 year. Of the 19.6GL of assumed inflow to the Millbrook reservoir and 10.1GL of inflow to the Kangaroo Creek reservoir (and Gorge Weir), only 6.1GL is used for water supply. This volume is transferred to the Anstey Hill WTP. The balance of around 23.6GL goes to evaporation (around 4.3GL) or is spilled over the Gorge Weir (around 19.3GL) and lost to the bulk water supply system. We discuss in Section 4.2 SA Water's trial environmental flow program, but as above, note that the volume lost over the Gorge Weir is far in excess of the trail volume (0.89GL). We conclude that the reason for the natural inflows to the Millbrook and Kangaroo Creek reservoirs not being used in this modelled scenario are largely due to:

  - The way that demand is distributed across WTPs (as discussed in Section 3.2.4) with the areas able to be served by Hope Valley WTP served instead via Happy Valley through the hard coding process shown in Figure 3-2. While this will in part be due to the additional water from the ADP supplied to Happy Valley WTP, this constraint may also be leading to water unnecessarily being drawn from the River Murray.

  - A restriction imposed within the modelling that Hope Valley not be used due to concerns over cryptosporidium risk. We observe that HOMA is not constructed to take into account operational risk except through coarse means such as switching Hope Valley off completely. Given that Hope Valley will have new filters installed to combat this cryptosporidium risk which will be operational at full capacity from 1 January 2013[10], we do not understand why Hope Valley has not been used in the RBP scenario presented. Not using this plant calls into question the investment on the filters at this plant. This result also calls into question whether SA Water's modelling is able to take into account the increased network flexibility offered to it by the NSIS.

> In the Barossa system, around 15.4GL of natural inflows are received in the year and the total end use at the Barossa WTP is 12.7GL. Therefore, the total inflows into the system are 15.4GL (inflows) + 8.4GL from the River Murray = 23.8GL. This is almost double the end use at the Barossa WTP and therefore suggests that the 8.4GL brought into this system is excessive.

[10] *Summary – Input to OpEx Assumptions,* SA Water, p10.

Based on the above observations, we recommend that SA Water re-run its HOMA modelling with the following changes made:

> Hope Valley WTP output for all years of the regulatory period to be at full capacity to make use of the new filters that have been installed. ADP water should be transferred to its next best use. If the process that SA Water uses to assign demand nodes to WTP cannot accurately determine the next best use of ADP water, then multiple scenarios should be run until the optimal solution found.

> Logical testing of the modelled outputs be performed so that unreasonable results such as River Murray water being spilled over weirs and lost to the system are avoided.

4.2 Analysis of spill volumes lost to the MLR reservoir system

Table 4-3 outlines the spills from reservoirs during the RBP years that are lost to the bulk supply system. These spill volumes were taken from HOMA output spreadsheets provided by SA Water. A minimum environmental flow release is specified for some of these river systems.

Table 4-3 Reservoir Spill RBP Estimates

River System	Environmental Flow Releases (GL/year)			
	Required Minimum	2013/14	2014/15	2015/16
South Para at Barossa Weir	2.24	2.24	2.24	2.24
River Torrens at Gorge Weir	0.89	22.20	22.20	1.43
Onkaparinga at Clarendon Weir	9.24	17.07	25.95	9.24
Myponga at Myponga Reservoir	0.00	0.68	2.02	1.94
TOTAL	12.37	42.19	52.41	14.85

As shown in Table 5-2 during the years when there is ADP water available, excess water, up to 40.04 GL/year (in 2014/15 which is 52.41GL – 12.37GL), is allowed to spill from the reservoirs. While some of this spill may be unavoidable due to the timing of inflows and demand, it is considered that optimising the operation of the reservoirs, WTPs and NSISP should reduce the volume of spill, reduce the volume of pumping required from the River Murray, and maximise the use of MLR inflows.

The most significant spills in excess of that target environmental flow levels occurs at the Gorge Weir. This appears to be driven, as noted in Section 4.1, by the Hope Valley WTP being underutilised and because it is assumed that Anstey Hill is supplied by the Mannum-Adelaide pipeline for the majority of the year due to concerns relating to *cryptosporidium* in the Millbrook reservoir. When questioned on the basis for limiting the volume of water supplied to Anstey Hill, SA Water responded that:

> *SA Water has completed extensive investigations into the risks associated with* Cryptosporidium*. A program of capital investment has been developed to address risks based on these investigations, including a detailed risk assessment. Of particular relevance to this analysis is that at Anstey Hill WTP, risk mitigation measures include an upgrade to process control systems and the appropriate selection of source water. The attached independent review conducted by the South Australian Centre for Economic Studies confirmed that this is the most prudent approach. The strategy developed in line with this recommendation is to only take water from Millbrook Reservoir between February and May each year while further studies are undertaken over the next 18 months. This also allows SA Water to delay an estimated $11M investment (approximate only) in UV disinfection that would otherwise be required to reduce water quality risks from Cryptosporidium to appropriate levels.*

We reviewed the report authored by the South Australian Centre for Economic Studies and found that it was largely an optioneering report used to select between different capital and operating expenditure options to address the observed cryptosporidium risk, Specifically for Anstey Hill, the options considered involve the following:

> Option A: take peak loads off Anstey Hill by using Hope Valley WTP supplied with water from the River Murray, use River Murray Water in preference to Millbrook Reservoir when ‘ there are higher levels of

cryptosporidium oocysts observed in Millbrook Reservoir' and upgrade of the monitoring and control system.

> Option B: install UV disinfection at Anstey Hill so that it can take Millbrook Reservoir water when it is available.

Therefore, this report as it relates to Anstey Hill WTP is only a cost-benefit analysis of the option of pumping water from the River Murray or installing UV disinfection at the WTP. It does not provide justification of the assumed operating regime of not using Anstey Hill for eight months of the year. By inference, SA Water equates times when 'there are higher levels of cryptosporidium oocysts observed in Millbrook Reservoir' as being the eight months of the year from June to January.

We question this operating strategy on the following grounds:

> Elevated *cryptosporidium* levels are typically associated with rain events when pollutants are flushed into reservoirs. Therefore, operational strategies used by other water service providers often include avoiding using sources known to have cryptosporidium risk after rain events Therefore, we would expect that an optimal operational strategy would target known risk factors, such as rain events, rather than adopting blanket bans. Greatly assisting such a strategy would be the advances in cryptosporidium detection noted in SA Water's *Drinking Water Quality Report 2010-11* (p31) that notes that SA Water has developed a test that is "rapid, highly sensitive and precise and will lead to increased confidence in our monitoring for these organisms".

> Another typically used operational strategy, and that noted by the ADWG's fact sheet on Cryptosporidium is to ensure effective operational of coagulation/filtration and filtration process units. The fact sheet notes that a 'turbidity limit of 0.2 NTU or less for effluent from individual filters has been shown to provide optimal removal of *cryptosporidium*'. We have observed this operational strategy, with online turbidity metering from filters, used commonly by other water service providers.

> River Murray Water contains significant other pollutants, therefore the risk from cryptosporidium, and costs of treatment, should be balanced against the risks from River Murray water and any additional cost for treatment of it.

Without analysis that addresses the above issues, we can see no reason why the option of Anstey Hill being supplied from Millbrook Reservoir should not be considered in more detail by SA Water instead of taken as a given by SA Water. Therefore, it is recommended that the following scenarios be tested by SA Water:

> Remove the assumption that Anstey Hill demand be supplied entirely by the Mannum – Adelaide pipeline for the majority of the year, and allow transfers from the Millbrook Reservoir . These results would be considered with reference to a risk management strategy for cryptosporidium that reflects the actual observed prevalence of cryptosporidium and appropriate operational strategies to address this problem.

> Allow increased transfers from the Happy Valley and Hope Valley WTPs to northern extremities of the water supply systems through the NSISP to minimise the volume of spill.

Some of the assumptions used in HOMA appear to have been based on previous operating years, when an alternate source of water from the ADP was not available. It appears that the operation of the ADP and NSISP has not yet been optimised in HOMA.

4.3 Conclusion

We have tested two specific areas of HOMA output given the limited time available. The results of our analysis described above appear to significantly cast doubt on the ability of HOMA to generate an optimised mix of water supply sources. In particular, we have identified that HOMA underutilises natural inflows to reservoirs (the lowest cost water source) and leads to unnecessary spilling of River Murray water over weirs and out of the bulk supply system.

By inspection, it appears that the discrepancies noted above are due to how the ADP volumes are integrated in the model and the inability of the way that demand is assigned to WTPs to accurately reflect the operational flexibility available to SA Water, particularly through the recently completed NSIS. A further reason is that it appears that the modelled results used for the RBP have been constrained to not use the Hope Valley WTP due to concerns over cryptosporidium. This is despite new filters to address the cryptosporidium risk being due for completion prior to the regulatory period.

5 Conclusions

From the discussion and analysis presented in the preceding sections, the following conclusions can be drawn:

Network configuration

> We believe that HOMA model contains significant rigidities in how the bulk water supply network is represented. In particular, we conclude that:

- The model does not effectively take account for the increased flexibility in bulk water transfer provided to SA Water by the NSISP. This increased flexibility as described by SA Water is set out in Section 3.3.5.
- The manner in which WTP demand is largely based on historic records with coarse manual, monthly adjustments does not adequately reflect the operational flexibility available to SA Water in practice. The model does not appear to have the ability to select lower cost WTPs over higher cost WTPs.
- The constraint that the Anstey Hill WTP can only be supplied by the Mannum-Adelaide pipeline (from the River Murray) throughout the year with the exception of four months between February and May may overestimate the volume of water required from the River Murray.

> System flows do not account accurately for system losses in transmission mains and natural losses beyond evaporation. This can result in an underestimation of pumping volumes and an underestimation of the catchment inflows.

> The model works on average month inputs and monthly time steps. This does not correlate directly to system operation where operating parameters are typically changed much more frequently – hourly, daily or weekly. SA Water produces a weekly operating instructions report. This will lead to variation between actual operation (where parameters can be varied more regularly) and modelled results which is fixed for a month at a time.

MLR reservoir inflows

> We consider that it is reasonable that the median catchment inflow determined from SA Water's reservoir water balance from the last 10 years be used for the purposes of RBP modelling. This is because of the observed and documented differences between the inflows determined by SA Water's mass balance and those determined by the alternative approach of forecasting using a catchment hydrology model.

> We conclude that there are a number of sources of inaccuracy in SA Water's water mass balance. SA Water does not appear to know the materiality of these inaccuracies. Sources of potential inaccuracy include:

- The reservoir storage and area curves used.
- No allowance for evaporation losses from the smaller reservoirs.
- No allowance for direct rainfall onto the reservoirs.
- No allowance for losses during transfers.

Costs

> It appears that fixed electricity costs for pumping are not included in HOMA. This constraint is likely to underestimate the cost of pumping water (from the River Murray) and therefore possibly 'overuses' this source in preference to other sources.

> The WTP operating costs in HOMA do not reflect actual costs and are very unlikely to reflect relative costs. However, as noted, the configuration of the model is such that it does not appear to have the ability to select lower cost WTPs over higher cost WTPs in any case.

HOMA results used in RBP

> In the 2013/14 year, the HOMA modelling results show that 4.1GL of water from the River Murray ends up being wasted to the system. Also, around 19.3GL of inflows are lost from the Gorge Weir that could have been used in place of water drawn from the River Murray.

> The water supplied to the Barossa system from the River Murray appears to be in excess of that required given the level of inflows.

> Analysis of the HOMA results used in the RBP show that when water from the ADP is available the reservoirs are allowed to spill in excess of the environmental flow requirements. While this may be due to timing of inflows, the volume (40GL/year) is significant and unlikely to reflect an optimised result.

On the basis of the above findings, we cannot conclude that the bulk water supply mix determined by SA Water for its RBP submission largely using its HOMA model represents an optimised result. Our major concerns are that:

> The configuration of the network in the model is rigid and does not reflect the flexibility of operation available to SA Water, in particular though:

- Operation of the NSISP.
- Assumption not to use Hope Valley WTP.
- Using least cost water treatment plants over higher cost plants.

> The monthly time steps in HOMA do not reflect the actual operational flexibility available to SA Water.

> The modelled results appear to include excessive spilling from reservoirs.

6 Recommendations

We recognise that there is a short term need for ESCoSA to assess matters relevant to SA Water's supply mix as represented in its RBP and a longer term need for SA Water to continually improve its supply mix optimisation. Therefore we make short term recommendations and recommendations for the medium term (nominally 6months – 2 years).

Short term recommendations

> Hope Valley WTP output for all years of the regulatory period to be at full capacity to make use of the new filters that have been installed. ADP water should be transferred to its next best use. If the process that SA Water uses to assign demand nodes to WTP cannot accurately determine the next best use of ADP water, then multiple scenarios should be run until the optimal solution found.

> Logical testing of the modelled outputs be performed so that unreasonable results such as River Murray water being spilled over weirs and lost to the system are avoided.

> Remodel the supply mix removing the assumption that Anstey Hill demand be supplied entirely by the Mannum – Adelaide pipeline for the majority of the year, and allow transfers from the Millbrook Reservoir. These results would be considered with reference to a risk management strategy for cryptosporidium that reflects the actual observed prevalence of cryptosporidium and appropriate operational strategies to address this problem. .

> Remodel the supply mix allowing increased transfers from the Happy Valley and Hope Valley WTPs to northern extremities of the water supply systems through the NSISP to minimise the volume of spill.

Medium term recommendations

> SA Water's reservoir mass balance model should be further refined, so that greater confidence in the average catchment inflows, and direct comparison with the catchment hydrology models can be achieved. We recommend that the following refinement to SA Water's reservoir mass balance be considered:

- Allowance for evaporation losses from the smaller reservoirs.
- Allowance for direct rainfall onto the reservoirs.
- Regular calibration checks of the rating curves or flowmeters used to determine transfer volumes and spills.
- Semi-regular reviews of the stage storage curves (the last review was conducted in 2008).
- Allowance for losses during transfers.
- Allowance for seepage from reservoirs. This can be determined through calibration of the reservoirs in WaterCress or use of typical seepage rates based on local soil conditions.
- Allowance for groundwater inflow if considered applicable.

> Ongoing efforts to reconcile SA Water's inflow estimates with those determined by DEWNR's hydrology models be made. This may include calibration of DEWNR's models using recent data.

> SA Water determine the level of accuracy (represented as a +/- accuracy band) associated with its reservoir inflow estimates.

> Accurate and up to date costs for pumping and treatment be included in the model.