Lessons Learned from the Vaal River System Reconciliation Strategy Study

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Abstract

Reconciling the available water resources of the Vaal River System with the future expected water requirements of the system is an essential and continuous management activity of the Department of Water Affairs and Forestry (DWAF). This function is carried out by developing a Reconciliation Strategy which has the aim of identifying and recommending intervention measures that would maintain a positive water balance for a twenty to thirty year planning period. DWAF has compiled the First Stage Reconciliation Strategy for the Vaal River System by implementing integrated water resource planning procedures which included among other things; the development of water requirement and return flow scenarios, evaluations of the water resource supply capability, determine scenarios of water loss savings through water conservation and demand management, assess the implications of the Reserve on the water balance, incorporate water quality management options, schedule future augmentation options and conducted stakeholder consultation in the development of the reconciliation strategy.

The study presented certain challenges and the outcome of the evaluations revealed the need for the implementation of decisive strategies to; curb unlawful water use in the catchment, implement water conservation and demand management measures as the only means to maintain a positive water balance over the medium term and the need for water quality management measures to reduce the risk of eutrophication, to mention a view.

Keywords: *Vaal River System, reconciliation strategy, water balance, water resource management..*

1 Introduction

The Large Bulk Water Supply Reconciliation Strategy Study for the Vaal River System Study has the purpose to develop a strategy for meeting the growing water requirements of the industrial and urban sectors that are served by the Integrated Vaal River System (IVRS). The need for the study was identified in the Internal Strategic Perspective (ISP) for the Vaal River System Overarching (**DWAF, 2004d**) and the key objectives were identified as follows:

- Update the current and future urban and agricultural water requirements.
- Assess the water resources and existing infrastructure.
- Take into account the Reserve requirements for alternative classifications.
- Formulate reconciliation interventions, both structural and administrative/regulatory.
- Conduct stakeholder consultation in the development of the strategies.

Parallel to the Reconciliation Study, the Directorate Water Use Efficiency of the Department of Water Affairs and Forestry (DWAF) acknowledged that the water requirement projection scenarios used in the ISP study did not explicitly include the effect of water conservation and water demand management initiatives (**DWAF, 2004d**) and as a result commissioned a Water Conservation and Water Demand Management study with particular focus on the Upper and Middle Vaal WMAs.

The ISPs further identified the need for integrated water quality management of the Vaal River and its major tributaries. Although there are several individual Catchment Management Strategies already completed, these strategies and their objectives need to be integrated and co-ordinated in a system context. To this end, the Directorate: National Water Resource Planning of DWAF has commissioned a study to develop an *Integrated Water Quality Management Plan* (**DWAF, 2006a**) for the Vaal River System which is running concurrently with the Reconciliation Study**.**

The core of the study area consists of the Upper, Middle and Lower Vaal River Water Management Areas (WMAs), however, due to the numerous inter-basin transfers that link this core area with other WMAs, reconciliation planning has to be undertaken in the context of the Integrated Vaal River System which also includes portions of the Komati, Usutu, Thukela and Senqu River (Located in Lesotho) catchments.

The management of the studies was therefore coordinated by combining the project management of the Water Conservation and Reconciliation studies and have cross representation of study managers on the Water Quality Study.

2 Study procedure and methodology

The overarching study approach was to develop reconciliation strategies in two stages. The first stage involved developing and assessing scenarios of possible future reconciliation options. The First Stage Reconciliation Strategy was presented to the Department of Water Affairs and Forestry (DWAF) Management and Stakeholders for comments. Further investigations were identified for assessment during the development of the **Second Stage Reconciliation Strategy** which is scheduled for completion by November 2007.

An essential part of the strategy development process was the integration of information from various processes and studies in order to arrive at a strategy that accounts for all major aspects that influence the bulk water supply situation in the Vaal River System.

During the inception phases of the abovementioned three studies, it was identified by the respective management teams that the integration of strategies and co-ordination of study activities would be essential to development coherent water resource management measures for the Vaal River System. An integrated stakeholder engagement process was therefore followed, which involved combined Project Management and Steering Committee meetings for the Reconciliation and WC/WDM studies. Furthermore, shared representation of DWAF management and study team members on the Reconciliation and Water Quality Management studies ensured the co-ordination of interdependent activities and integration with the proposed water quality management measures was achieved.

The focus of the assessments for the First Stage Strategy included the following:

- Develop water requirement and return flow scenarios.
- Determine the potential for Water Conservation and Demand Management by concentrating on the main urban areas.
- Estimate the irrigation water requirements and compile possible future scenarios.
- Identify and assess potential large scale water reuse options.
- Provide an initial indication of how the implementation of the Ecological Water Requirements could influence the projected water balance situation.
- Preliminary analysis of existing water quality management options relating to blending, dilution and water reuse.

The subsequent sections describe the procedures and results of the above listed assessments.

3 Water requirement scenarios

3.1 Irrigation

Irrigation's water requirements comprise about thirty five percent of the total system water use, of which the Vaalharts Irrigation Scheme, the largest in the country, uses 31% of this sector's water. The *Internal Strategic Perspective: Vaal River System: Overarching* **(DWAF,2004d)** indicated that, due to the strategic decision that any new water use will have to pay the full cost of water, irrigation water use is likely to remain constant. The Water Resource Managers in the regions, however, expressed their concern, in that they suspected that substantial irrigation developments had taken place since 1998, most of which is perceived to be unlawful. This lead to the commissioning of a water use validation study in the Upper Vaal WMA, from which preliminary information was received and assessed in this assesment.

The assessment of the irrigation water requirements revealed that the estimated water use in the year 2005 for this sector is 1060 million m^3/annum, which is 294 million m^3/annum higher than what was applied in previous investigations. Preliminary results from the Upper Vaal Water Management Area Validation Study indicated that as much as 241 million m^3/annum of the year 2005 irrigation water use could be unlawful. Furthermore the total registered water use for irrigation in the Vaal River System is estimated to be 1 375 million m^3/annum and is an indication that the increasing trend that was experienced since 1998 could continue further if interventions to curb unlawful water use are not successful.

3.1.1 Scenarios of future irrigation water use

The information presented above focused on the historical and current irrigation water use. For planning purposes it is required to compile scenarios of future water use for the period up to 2030. Given that the current (year 2005) water use estimates are significantly higher than the preliminary estimates of what is considered lawful, a scenario was compiled where it was assumed that the current water use will be reduced over the medium term through legal interventions and water use compliance monitoring. The assumptions used in the scenario are listed below:

Irrigation Scenario 1: Curtailment of unlawfull irrigation water use

- **Upper Vaal WMA**
  - Assume the growing trend, which was observed over the period 1998 to 2005, continuous for two years until 2008. This implies the interventions will take two years to become effective.
  - Eradication of unlawful irrigation water use from 2008 onwards and assumes the water use will decrease over a period of 3 years.
  - The assumption is made that the interventions will reduce the irrigation to the lawful volume plus 15% and that this will be achieved in the year 2011. The additional 15% above the estimates of the lawful water use is a conservative assumption providing for possible under estimations from the current data.

- **Middle and Lower Vaal WMA**
  - Due to the absence of information from validation studies in these areas, it is assumed that the current suggested irrigation water use will remain constant over the planning period.

Irrigation Scenario 2: Recent trend continues unabated

- **Upper Vaal WMA**
  - The assumption was made that the irrigation water use will continue to increase at the trend observed between 1998 and 2005 until the registered volume from the WARMS database is reached.

- **Middle and Lower Vaal WMA**
  - Assume the future water use remains constant at the suggested water use levels.

The **Irrigation Scenario 2** will create an unsustainable situation in the Vaal River System and is not considered to be viable. However, this scenario was derived to illustrate the potential impact should the situation arise where the interventions are not successful to cut back the unlawful water use.

3.1.2 Future irrigation water use scenario results

Figure 1 presents the future irrigation water requirements for the two scenarios described above and shows that the **Irrigation scenario 2** is about 450 million m^3/annum higher than the **Irrigation Scenario 1** over the long term. These two irrigation water requirement scenarios were used in the system planning scenarios as discussed in **Section 4.2**.

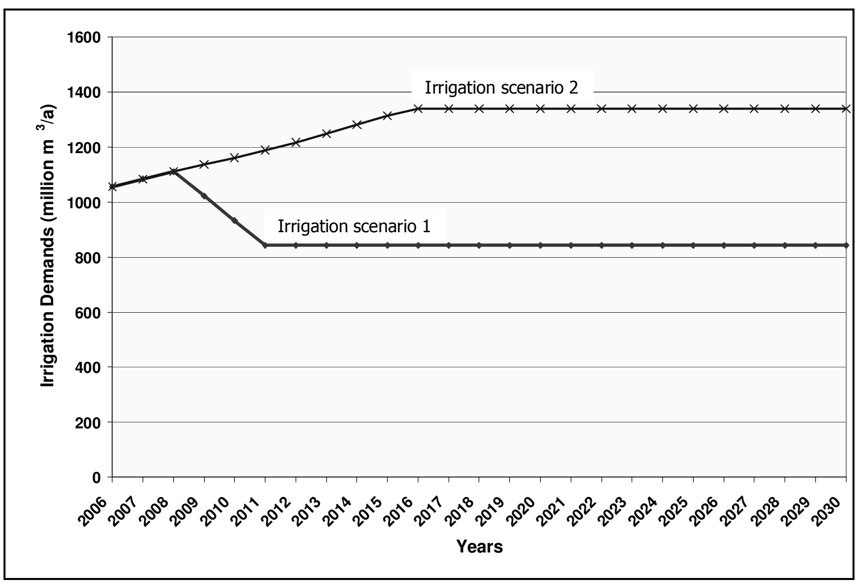


Figure 1: Irrigation water requirement scenarios for the Vaal River System

3.2 Water requirements for Eskom, Sasol and Mittal Steel

Water requirement scenarios for the three large industries **Eskom, Sasol** and **Mittal Steel** were provided by the respective organisation for the development of the strategy and are described below.

Eskom currently operates 12 coal fired electrical power stations, which receive water from the Integrated Vaal River System. Some of these stations were decommissioned and are now reinstated to increase supply in response to the growing demand for electrical power to fuel the South African economy. There are also plans to develop three new power stations, envisaged to receive water from the Vaal River System. Two are scheduled to receive water from Vaal Dam, and current planning is that the third will be located close to the existing Kendal Power Station and receive water from the Eastern Vaal River Sub-system (a component of the Integrated Vaal River System). The water requirement scenario that was used in the planning analysis indicated that the total water demand for all the power stations is expected to increase from 313 million m^3 in the year 2006 to 397 million m^3 in the year 2030.

Sasol has two plants receiving water from the Integrated Vaal River System. The Sasol Secunda Complex's primary source of water is Grootdraai Dam, which will be supported through the Vaal River Eastern Sub-system Augmentation Project (VRESAP) once it is operational in 2008. The Sasol Sasolburg Complex is supplied from Vaal Dam, which is supported from the Thukela-Vaal Transfer Scheme, as well as the Lesotho Highlands Water Project. The water requirements for the two complexes combined are expected to increase from 119 million m^3 in the year 2006 to 166 million m^3 in the year 2030.

Mittal Steel receives its water from Vaal Dam, and in their projections (reference July 2006) they are planning to decrease their current water use from 17.4 million m^3 in the year 2006 to 16.6 million m^3/annum in the year 2010, from where the water use remains constant for the subsequent years of the planning period.

3.3 Water requirements for the urban sector

Urban water requirement scenarios were developed for the **Rand Water supply area** by applying the Water Requirement and Return Flow Model (**DWAF, 2004e**) for the planning period up to 2030. One of the driver variables in the model is population scenarios which were obtained from a parallel study that was carried out by the Directorate: Water Resource Planning Systems of the DWAF. Two future population scenarios were developed, the first scenario was made available in January 2005 and, after a review and comparison with information that was produced by Statistics South Africa (**Stats SA, 2006**), the second scenario was developed in August 2006. A further population scenario, based on the National Water Resource Strategy (NWRS) Population, was applied for the purpose of producing an alternative water requirement and return flow scenario.

The Water Requirement and Return Flow Model was configured for 47 Sewage Drainage Areas (SDAs) and calibrated for the year 2001 (year for which census data was available). The calibration involved changing model parameters to match both the water use and return flows observed for each SDA for the year 2001. The 47 SDAs were divided into those draining into the Crocodile River System (Northern SDAs) and those discharging into the Vaal River System (Southern SDAs).

Water requirement and return flow scenarios were compiled based on the NWRS population scenarios (**Scenario A**) and the August 2006 DWAF population scenario (**Scenario B**) for the Rand Water supply area.

Water requirement scenarios for **Sedibeng Water** and **MidVaal Water Company** were obtained from the respective organisations and for all the **other urban areas** the water requirement projections were determined using the growth rates from the National Water Resource Strategy (NWRS). Where actual water use data were available, the starting point (volume for the first year in the projection) was adjusted to match the actual value on which the future growths were applied.
Tables 1 and **2**, respectively provides a summary of the water requirements and return flows for **Scenarios A** and **B**.

3.4 Potential savings through water conservation and water demand management measures

The parallel study to determine the potential savings that can be achieved through water conservation and water demand management (WC/WDM) in the Vaal River System (**DWAF, 2006b**) was commissioned by the Directorate: Water Use Efficiency, and a high level of integration with the Reconciliation Study assured that the products of the two studies were aligned.

The focus of the WC/WDM assessment was on the nine largest urban water users, which in total used 1 186 million m^3/annum of water in the year 2004, as listed in **Table 3**.
A standard water balance was undertaken for each municipality, which was built up from assessments of water supply zones in their respective supply areas to represent the actual conditions in each zone. An illustration of the components that make up the water balance is provided in **Figure 2,** indicating the losses and non-revenue water. From this water balance the potential savings were determined with the focus on the "Billed but not paid for consumption" as well as the "Potential savings on physical leakage" (hashed blocks) components.

Table 1: Summary of water requirements and return flows (Scenario A)

Water users	Planning years					
	2006	2010	2015	2020	2025	2030
Water Requirements						
Rand Water	1297	1338	1417	1481	1568	1666
Mittal Steel	17	17	17	17	17	17
ESKOM	330	381	407	416	417	416
SASOL (Sasolburg)	24	27	30	33	37	41
SASOL (Secunda)	92	104	108	112	117	123
Midvaal Water Company	35	35	35	35	35	35
Sedibeng Water (Balkfontein only)	41	41	41	41	42	43
Other towns and industries	161	163	167	167	167	168
Vaalharts/Lower Vaal irrigation	542	542	542	542	542	542
Other irrigation	722	599	500	500	500	500
Wetland / River Losses	325	326	327	329	330	331
Return Flows						
Southern Gauteng (Rand Water)	331	343	359	372	386	400
Midvaal Water Company	1	1	1	1	1	1
Sedibeng Water	2	2	2	2	2	2
Other towns and industries	61	65	69	72	76	80
Irrigation	60	48	38	38	38	38
Mine dewatering	114	105	121	123	121	121
Increased urban runoff	101	103	107	113	121	129
OVERALL GROSS SYSTEM DEMAND:	3587	3572	3590	3672	37711	3881
OVERALL NET SYSTEM DEMAND:	2917	2905	2893	2950	3025	3108

Notes: (1) All volumetric values are given in million m^3/annum.

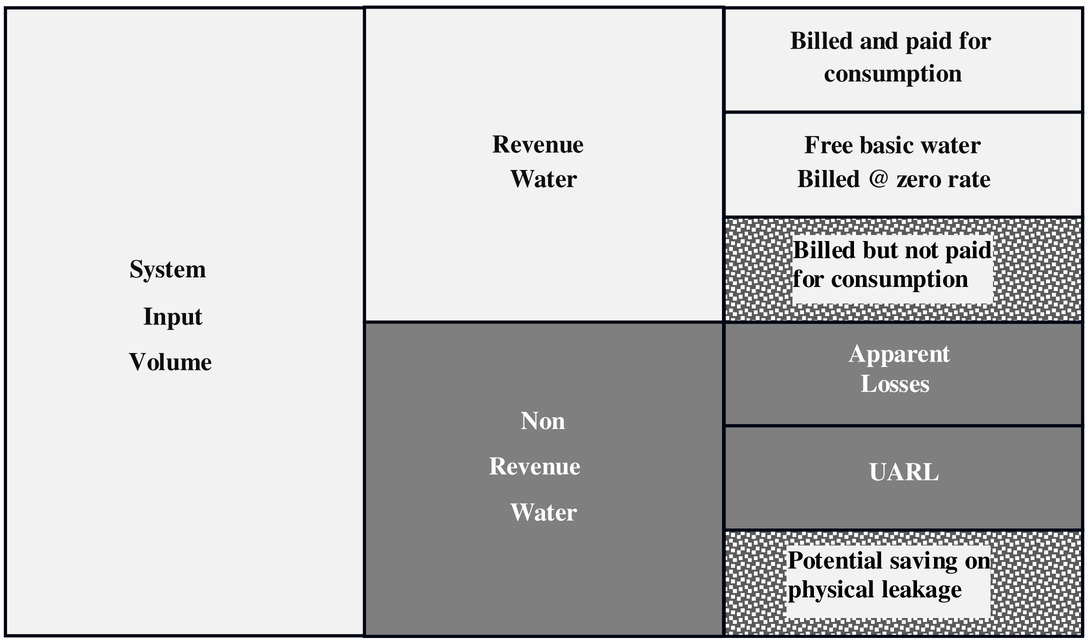
Table 2: Summary of water requirements and return flows (Scenario B)

Water users	Planning years					
	2006	2010	2015	2020	2025	2030
Water Requirements						
Rand Water	1308	1390	1498	1582	1665	1753
Mittal Steel	17	17	17	17	17	17
ESKOM	330	381	407	416	417	416
SASOL (Sasolburg)	24	27	30	33	37	41
SASOL (Secunda)	92	104	108	112	117	123
Midvaal Water Company	35	35	35	35	35	35
Sedibeng Water (Balkfontein only)	41	41	41	41	42	43
Other towns and industries	161	163	167	167	167	168
Vaalharts/Lower Vaal irrigation	542	542	542	542	542	542
Other irrigation	722	599	500	500	500	500
Wetland / River Losses	325	326	327	329	330	331
Return Flows						
Southern Gauteng (Rand Water)	335	362	392	418	438	459
Midvaal Water Company	1	1	1	1	1	1
Sedibeng Water	2	2	2	2	2	2
Other towns and industries	61	65	69	72	76	80
Irrigation	60	48	38	38	38	38
Mine dewatering	114	105	121	123	121	121
Increased urban runoff	101	103	107	113	121	129
OVERALL GROSS SYSTEM DEMAND:	3597	3624	3672	3773	3868	3967
OVERALL NET SYSTEM DEMAND:	2923	2939	2942	3005	3071	3136

Notes: (1) All volumetric values are given in million m^3/annum.

Table 3: Major municipal demands considered in the study listed in descending order

Municipality	*Water use in the year 2004 (million m^3)*
Johannesburg	**470**
Ekurhuleni	**291**
Tshwane	**255**
Emfuleni	**79**
Rustenburg	**26**
Mogale	**24**
Govan Mbeki	**18**
Matjhabeng	**16**
Randfontein	**7**
Total	**1 186**



Notes: UARL – Unavoidable Real Losses

Figure 2: Illustration of a standard water balance

Based on detailed assessments made on numerous supply zones in each municipal area, the potential savings coupled with a range of WC/WDM measures were determined. With the knowledge that these measures will require substantial financial and human resources to implement, a schedule (projection) of future savings were made, resulting in the development of three scenarios.

The savings were applied to the water requirement of **Scenario B** (see **Table 2**) and were labelled **Scenarios C**, **D** and **E** respectively.

The description and saving results from the scenarios are as following:

- **Scenario C**: 5 Year water loss programme where water wastages are reduced through measures such as leak detection and repair. The loss management measures are maintained after the five year period. This scenario also include measures to improve the efficiency of water use and the assumption was made that a 1% saving can be gained per annum from the year 2015 onwards for the entire planning period (1% of selected large urban users that were assessed in detail).
- **Scenario D**: Reduction in wastage over 5 years. No efficiency improvement measures were included in this scenario.
- **Scenario E**: Reduction in wastage over 10 years, allowing for a slower implementation period of the proposed measures.

The three tables below (**Tables 4**, **5** and **6**) present the savings that can be achieved for each of the scenarios described above (savings are shown in **Row b** of each tables). It was assumed that the WC/WDM measures will also impact on the return flows as reflected in **Row c** of each table. The overall impact on the net system water requirement is determined in **Row d,** and **Row e** provides the total system net water requirement.

Table 4: Savings and system net water requirements for Scenario C

Component description	Row	Calculation or Reference	Planning Years					
			2006	**2010**	**2015**	**2020**	**2025**	**2030**
Net system demand for **Scenario B**	a	From **Table 3**	2923	2939	2942	3005	3071	3136
Reduction in Water Requirements **Sc. C**	b	Assessment	-	177	272	329	379	378
Reduction in Southern SDA Return Flows **Sc. C**	c	Assessment	-	69	91	110	126	135
Net reduction **Sc. C**	d	(b-c)	35	109	181	219	253	243
System net demand **Sc. C**	e	(a-d)	2888	2830	2761	2786	2818	2893

Note: *(1) All volumetric values are given in million m³/annum.*

Table 5: Savings and system net water requirements for Scenario D

Component description	Row	Calculation or Reference	Planning Years					
			2006	**2010**	**2015**	**2020**	**2025**	**2030**
Net system demand for **Scenario B**	a	From **Table 3**	2923	2939	2942	3005	3071	3136
Reduction in Water Requirements **Sc. D**	b	Assessment	-	180	191	200	213	213
Reduction in Southern SDA Return Flows **Sc. D**	c	Assessment	-	68	75	81	87	93
Net reduction **Sc. D**	d	(b-c)	23	112	117	120	126	120
Net system demand **Sc. D**	e	(a-d)	2900	2827	2826	2885	2945	3016

Note: *(1) All volumetric values are given in million m³/annum.*

Table 6: Savings and system net water requirements for Scenario E

Component description	Row	Calculation or Reference	Planning Years					
			2006	**2010**	**2015**	**2020**	**2025**	**2030**
Net system demand for **Scenario B**	a	From **Table 3**	2923	2939	2942	3005	3071	3136
Reduction in Water Requirements **Sc. E**	b	Assessment	-	110	176	193	206	208
Reduction in Southern SDA Return Flows **Sc. E**	c	Assessment	-	45	71	77	84	90
Net reduction **Sc. E**	d	(b-c)	13	65	105	115	122	118
Net system demand **Sc. E**	e	(a-d)	2910	2874	2837	2890	2949	3019

Notes: *(1) All volumetric values are given in million m³/annum.*

These water requirements and return flows were used to compile the planning scenarios, which are presented in **Section 4.2**

3.5 WC/WDM related Conclusions and Recommendations

From the assessment of the scope for WC/WDM several key issues were identified, from which the following conclusions and recommendations were made:

- WC/WDM can provide a significant reduction in the water demands in the study area, if the measures are implemented properly and maintained indefinitely. The cost of implementing WC/WDM measures is often less that the maintenance costs, which are often overlooked, with the result that the WC/WDM interventions fail within a year or two of being implemented.

- WC/WDM can be effective and sustainable as has been shown by several large projects undertaken in the study area, including:
  - The Sebokeng/Evaton pressure management project.
  - The Soweto leak repair, retrofitting and pre-paid metering project.
  - The Kagiso pre-paid metering project.

- Garden irrigation, using potable water, is a huge problem in many low income areas where indiscriminate use of hosepipes and potable water is creating both supply and pressure problems. The use of hosepipes must be either banned completely in such areas, or the use restricted to an hour or two every 2nd day during off-peak periods. Irrigation during the hottest part of the day (from 10h00 to 18h00) should be prohibited simply on efficiency grounds.

- Government Departments must co-ordinate their efforts with regard to WC/WDM. The efforts of DWAF, where the Department is spending large budgets to educate consumers on the evils of hosepipe irrigation, is being undermined by the efforts of the Department of Agriculture, as they are providing free hosepipes to the same consumers to grow vegetables. Those wishing to grow vegetables in such areas should be provided with buckets or watering cans, which can still be used with good effect without causing the system problems mentioned previously. Alternatively, roof tanks should be provided to capture rainwater, which is ideal for such irrigation.

- DWAF should encourage WDM activities – e.g. fund projects like Sebokeng, provide subsidies for roof tanks and low flush toilets, etc. The Department should not encourage use of low quality fixtures in township retrofitting projects and should rather use the highest quality pipes, meters and fittings for poor areas, since the taps and toilets in these areas experience highest use and lower quality fittings will not last.

- Lack of maintenance will result in many systems deteriorating into intermittent supply if action is not taken quickly – particularly in township systems where lack of maintenance has occurred over past 30 years.

- Municipalities should be encouraged to combine technical and financial services into a single unit, – current trend of separate billing/treasury from water supply/technical is causing major problems, and a proper water audit is often not possible, since the split between Real and Apparent losses cannot be established with confidence.

A summary of the estimated savings in the water requirements of the three above-mentioned scenarios are presented in **Table 7.**

Table 7: Savings for the indicated planning years: Scenarios C, D and E compared to Scenario B

Scenarios	Planning Years				
	2010	**2015**	**2020**	**2025**	**2030**
C	177 (11%)	272 (16%)	329 (18%)	379 (20%)	378 (19%)
D	180 (11%)	191 (11%)	200 (11%)	213 (11%)	213 (11%)
E	110 (7%)	176 (10%)	193 (11%)	206 (11%)	208 (10%)

Notes: (1) *All volumetric values are given in million m^3/annum.*
(2) *Values in brackets give the percentage reduction in the total system urban demand from **Scenario B**. The urban demand include the following components; Rand Water, Midvaal Water Company, Sedibeng Water and "Other towns and industries" as listed in **Table 2**.*

4 Future intervention requirements and augmentation schemes

Given the water requirement and return flow scenarios and the potential saving scenarios through WC/WDM measures presented in the previous sections, the need for intervention (when further WC/WDM measures and/or the development of an augmentation scheme are required) was determined by assessing the water reconciliation (water balance) situation over the planning period. This was undertaken by firstly defining the planning scenarios and, secondly, carrying out scheduling analysis to determine the date when further intervention should be required (see description of planning scenarios in a subsequent section).

4.1 Infrastructure intervention options

The Vaal Augmentation Planning Study (VAPS), completed in 1996, concluded that either a further phase of the Lesotho Highlands Water Project (LHWP) or further water resource developments in the Thukela River System could be considered as alternatives for augmenting the water resources of the Vaal River System.

The Thukela Water Project Feasibility Study (TWPFS) determined the most feasible scheme configuration for development in the Thukela River System. The study concluded that two proposed dams, one on the Bushman's River (Mielietuin Dam) and the other on the main stem of the Thukela River (Jana Dam), with transfer infrastructure, would be the most feasible scheme configuration to provide a nominal transferable yield of 15m^3/s (473 million m^3/annum).

A further study, the "Thukela Water Project Decision Support Phase" (TWPDSP) study, was carried out to, among other things, undertake a Comprehensive Reserve Determination Study for the Thukela River System and compile an implementation programme for the TWP. The results from this study indicated that the first water could be delivered twelve years after the decision is taken to proceed with the development. The Historic Firm Yield of the TWP, incorporating the Ecological Water Requirements (EWR), for the largest dam sizes was determined to be 454 million m^3/annum.

A joint feasibility study by the South African and Lesotho governments was commissioned in 2005 with the purpose of identifying the most feasible further phases of a scheme in Lesotho. Results from the first phase of the study were made available to the Reconciliation Study Team which indicated the proposed Polihali Dam with transfer infrastructure as the preferred option. The implementation period required for the scheme was estimated to be ten years after the decision is taken to proceed with the scheme. (If the decision is taken immediately, however, a further three years preparation phase has to be added to the ten years. This is to complete the current feasibility study and to investigate funding options.) The Historical Firm Yield of the Polihali Dam option was determined to be 458 million m^3/annum.

The second phase of the LHFP Feasibility Study commenced in October 2006 and the reconciliation results presented in this report will be used initially to determine the optimal configuration during that study. Updated water requirement projection scenarios is expected from the bulk water users Eskom and SASOL, and these scenarios will be incorporated into the second phase of the Vaal River System: Reconciliation Strategy Study.

4.2 Planning scenarios

Given the water requirement and return flow scenarios as well as the WC/WDM saving options, the following planning scenarios were compiled for analysis of the water balance:

- **Scenario A**: National Water Resource Strategy (NWRS) population scenario for urban water requirements.
- **Scenario B**: August '06 DWAF population scenario applied for the urban water requirements.
- **Scenario C**: Implement the savings of all identified WC/WDM measures based on the water requirements of **Scenario B**.
- **Scenario D**: Implement waste management initiatives over 5 years based on the water requirements of **Scenario B**.
- **Scenario E**: Implement waste management initiatives over 10 years based on the water requirements of **Scenario B**.

NOTE: All the above scenarios assumed the unlawful irrigation water use is removed (Irrigation Scenario 1 from **Figure 1** is implemented).

Figure 3 presents the net system demand compared to the supply capability of the system and the following conclusions can be drawn from the results:

- The unlawful water use in the irrigation sector results in the system being in a deficit situation from 2007 to 2009 for all the scenarios.
- Based on the projected balance situation for **Scenario B**, it is shown that the system will require intervention by the year 2013.
- If the potential savings through WC/WDM of **Scenario C** is achieved, no further intervention is required for the planning period until after the year 2030.
- The balance situation for **Scenarios D** and **E** shows that by eliminating wastage through WC/WDM further intervention is only required in the year 2023.

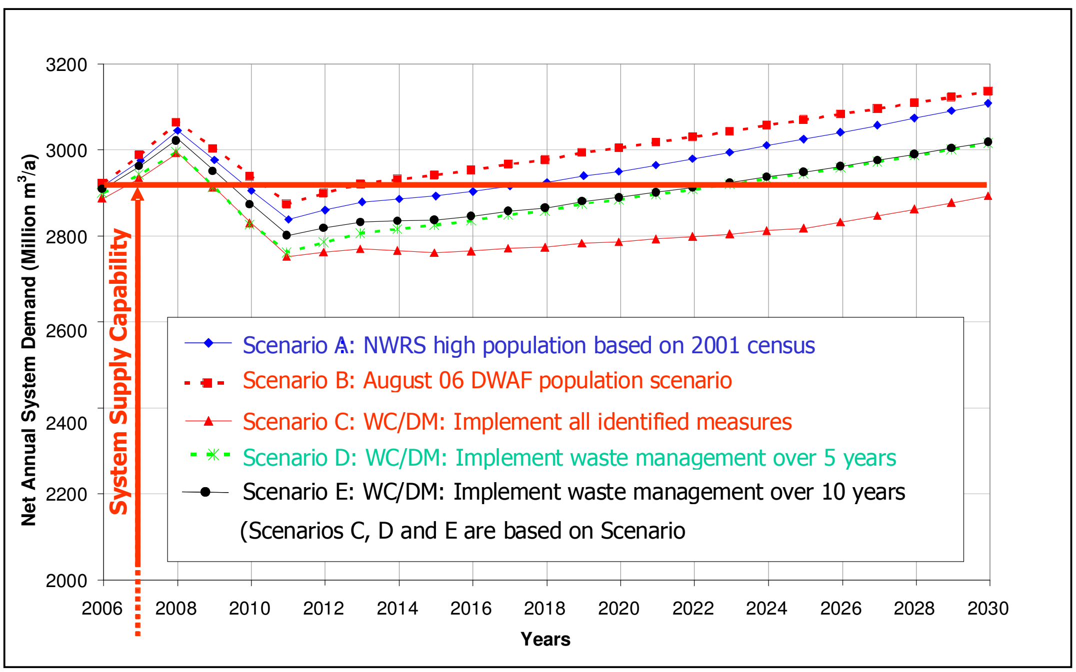


Figure 3: Net system demand and system supply capability

4.3 Reconciliation assessment

Reconciliation assessments were carried out by selecting a water requirement scenario from **Figure 2** and adding the supply capability (yield) of an augmentation scheme to the yield of the existing system. The date when the augmentation option is implemented dependants on either the first occurrence of a supply deficit (the year when the system net demand exceeds the system supply capability) or the earliest implementation date according to the project timeline requirements.

Figure 4 shows the reconciliation option based on the Scenario B water requirement and the Thukela Water Project (TWP) as augmentation option. Although the TWP is capable of supplying the required water over the long term, there are short term deficits (up to 2010 due to the unlawful water use) and medium term deficits (from 2015 to 2018 due to the project timeline requirements). A similar outcome was observed (results not shown in the paper) with the scheduling of the Lesotho Highlands Further Phases (LHFP).

The above result illustrates that WC/WDM is the only intervention measure that can be implemented to achieve a positive water balance over the medium term. The reconciliation situation based on **Scenario D** (including WC/WDM measures) indicates that the need for augmentation is postponed to 2023 (see **Figure 3**) and that both the TWP and LHFP is capable of supporting the long term water requirement growth.

An alternative irrigation water requirement scenario (**Scenario F**) was compiled where it was assumed the unlawful irrigation could not be reduced (see **Figure 5**). The purpose of this option was to illustrate that large deficits in the water balance will occur if the unlawful irrigation is not removed. This will result in large water restrictions over the medium term and significant capital investment in the long term, which is considered to be unsustainable.

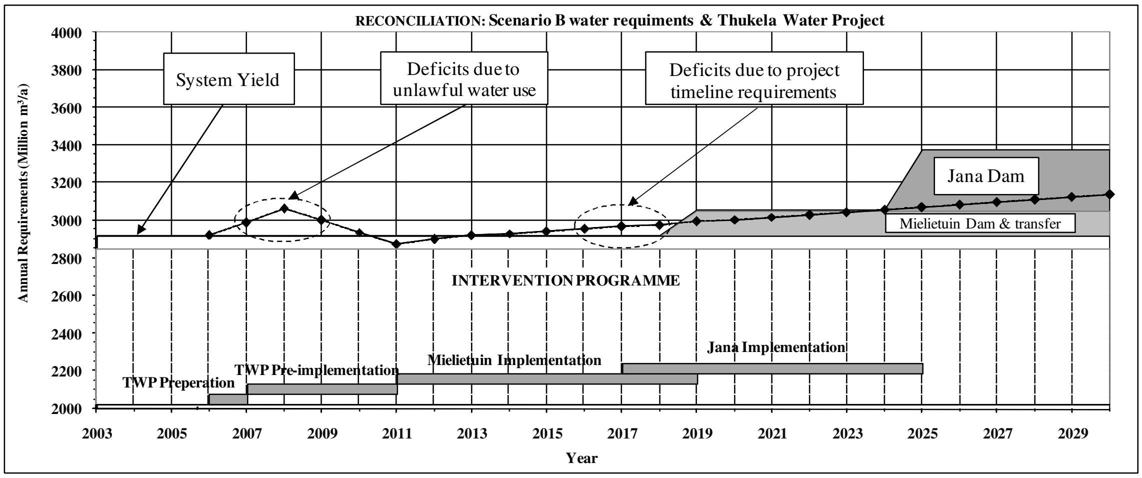


Figure 4: Reconciliation option for Scenario B water requirements and Thukela Water Project

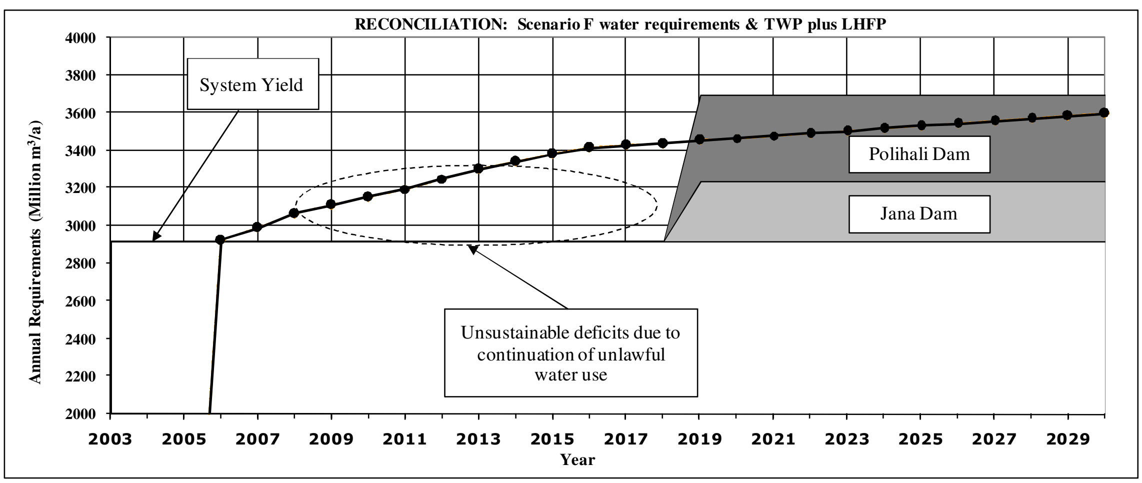


Figure 5: Reconciliation option for Scenario F water requirements and TWP plus LHFP

5 Perspective on water quality management

Water quality management is being investigated in detail as part of the parallel "***Integrated Water Quality Management Plan***" (IWQMP) study. At the time of writing this paper, the IWQMP (**DWAF, 2006a**) study was still in progress, and only preliminary results were available for consideration in the First Stage Reconciliation Strategy. The following section, therefore, provides a brief discussion of the main issues and findings regarding water quality management.

5.1 Water quality management considerations

Sporadic elevated aluminium concentrations were observed in Vaal Dam at the confluence of the Wilge and Vaal Rivers. The source of the aluminium is thought to be the Wilge River tributary downstream of the confluence with the Liebenbergsvlei River where pH of 6.0 have been recorded. Although no reports were received of aquatic organism deaths (no fish kills were observed), the elevated aluminium concentrations are a potential threat that requires management intervention. Further investigations are, however, required to improve the knowledge regarding the sources of the aluminium so that possible management measures can be evaluated.

The water quality situation in and downstream of the Vaal Barrage requires an intervention strategy for the management of salinity and nutrients. There are serious risks of eutrophic conditions in the river reach between Vaal Dam and Bloemhof Dam, which requires immediate intervention measures as well as long term strategies for reducing the nutrient load in the system.

Initial indications are that flow management measures, supported by intensive monitoring, could help to alleviate the risk over the short term. The impact of such releases (from Vaal Dam) on the supply capability of the system has to be assessed, which is a proposed activity for the ***Second Stage Reconciliation Strategy***.

Preliminary results indicated that the nutrient load (Phosphate) in the system can be reduced by adding secondary treatment processes to the existing major urban waste water treatment works, using existing and proven technologies. The costs of implementing such treatment processes are considerable, however, the environmental benefits would most likely favour this option as a long term solution. Further investigations will be carried out on these options as part of the IWQMP study.

Initial analysis of the dilution rule (where water is released from Vaal Dam to reduce the Total Dissolved Solids (TDS) Concentration in and downstream of Vaal Barrage) indicated that this option would only be feasible over the medium term (<8 years) and other options, such as desalination and source control, would have to be considered for the long term management of salinity. This is due to the fact that the dilution rule will result in excess water in Bloemhof Dam from about 2012 onwards.

It is however possible to utilise the excess water in Bloemhof Dam to support the Orange River at the time of the next augmentation from the LHFP or when the Orange system demand exceeds the current system yield by approximately 2015. This means that under these conditions it will be possible to continue with the dilution rule for a longer period, which in turn postpones the need for costly desalination.

Analyses were carried out with the Water Resource Planning Model (WRPM) to obtain an indication of the benefits, should desalination of mine discharges be implemented. Two scenarios were analysed with the WRPM, the first option with the discharges from the mines returned to the river (base case), and the second where the mine and industry discharges were treated to 250 mg/ℓ TDS and discharged back to river.

Table 8: Summarised results of desalination scenario

System monitoring point location	Option description (Total Dissolved Solids Concentration, mg/l)	
	Option 1 No desalination	Option 2 Desalination to 250mg/l
Vaal Barrage	750 (900)	500 (800)
Midvaal	750 (920)	600 (650)
Sedibeng	800 (1000)	600 (650)
Bloemhof Dam	500 (900)	400 (700)
Vaal Harts weir	550 (950)	420 (720)

Notes:
(1) Values without brackets are for the median of the distribution.
(2) Values in brackets are the 95 percentile of the distribution.

The summarised results of simulation analyses for 1000 stochastic sequences that were carried with the WRPM are presented in **Table 8**, which indicates that the benefit of the desalination option is between 100 and 200 mg/ℓ reduction in the TDS concentration. The economic benefit and cost/benefit analysis will be undertaken as part of the IWQMP study to determine the feasibility of this measure.

6 Strategic perspective

The findings from the water reconciliation scenario results points to specific strategies required for the sustainable management of the water resource of the Vaal River System. These strategies are presented in the subsequent sections, and the intention is that projects and programmes need to be development, and human and financial resources made available to achieve the underlying objectives.

6.1 Eradicate unlawful water use

The eradication of the unlawful water use, mainly in the irrigation sector, is an essential strategy that has to be implemented in order to rectify the current deficit (negative water balance) in the Vaal River System. The legal actions and procedures that will be implemented, should be designed to achieve legal precedence's to protect the entitlements of lawful water users, and assist in compliance monitoring and water use regulation in future.

6.2 Complete the Validation studies for the Vaal WMAs

The completion of the validation studies in the three Vaal Water Management Areas is required to obtain a reliable estimate of the situation regarding the irrigation water use in the Vaal River System. A product of the validation studies should be an assessment of the lawful water use. The results from the validation studies should be used to revise the projected water balance of the system.

6.3 Incorporate Taung Dam utilisation study results

The Directorate: Option Analysis of DWAF has at the end of 2006, commissioned a study to assess options for the potential utilisation of Taung Dam. The original purpose of the dam was to augment the supply to the Taung Irrigation Scheme, however, the infrastructure to convey water from the dam was not constructed, with the result that the dam is currently not being utilised.

The above-mentioned study has the purpose of investigating all possible uses of the dam, as well as determines the most feasible infrastructure to convey the water to the intended users.

6.4 Implement water conservation and demand management measures

The continuation of current, and the initiation of further WC/WDM projects, are essential to maintain a positive water balance in the Vaal River System. The potential savings that can be achieved through the reduction of water wastage is sufficient to delay the decision to proceed with an infrastructural option to the year 2012.
The report "*Potential Savings through WC/WDM in the Upper and Middle Vaal Water Management Areas*" (DWAF, 2006b), provides detail information on the types of WC/WDM measures that should be considered in each target municipality. This serves as a point of departure for the development of projects and securing on budget funds for WC/WDM measures.

The responsibility for the implementation of WC/WDM measures reside primarily with the municipalities and their water service providers. DWAF and provincial government should provide an active supporting role in the form of appropriate legislation and regulations, as well as making dedicated financing available in areas where resources are limited or lacking at municipalities.

The WC/WDM approach to be followed in the irrigation sector is that all savings, to be achieved, will be made available for further irrigation developments with priority given to the establishment of resource poor farmers.

6.5 Management intervention to reduce risk of eutrophic conditions

The high risk of eutrophic conditions in the Vaal River reach from Vaal Barrage to Bloemhof Dam requires water resource management intervention. Over the short term the situation could be improved by releases from Vaal Dam, however, current assessments point to the need for the removal of nutrients from the urban wastewater treatment works through secondary treatments processes. These management measures will be further investigated in the Integrated Water Quality Management Study (**DWAF, 2006a**).

6.6 Monitor net system water demand

In the past, annual monitoring was carried out only of the main water user's requirements from the Vaal River System. Due to the importance of urban return flows, and the impact WC/WDM could have on the return flows, it is required to also implement continuous monitoring of the return flows, to be able to determine the net water requirements of the system. This will enable regular updates of the water balance and monitoring of the situation against the scenarios presented in the document. System Water Balance Status Reports should be compiled annually to maintain a continuous record of the water balance, and detect deviations from the scenarios.

It is proposed that the System Water Balance Status Reports incorporate water requirement and return flow information for each of the main municipalities, i.e. Johannesburg, Tshwane, Ekhuruleni, Emfuleni, Rustenburg, Mogale, Govan Mbeki, Matjhabeng and Randfontein. Although not all of these municipalities return water to the Vaal River System, the information will be used to understand the impact of WC/WDM and to compile a similar report for the Crocodile (West) River System.

6.7 Completion of Lesotho Highlands Further Phases Feasibility study

The second phase of the Lesotho Highlands Further Phases Study should be completed based on the water balance resutwplts of **Scenarios B** and **D**. Once the optimal LHFP scheme has been identified, it will be required to undertake a comparison with the optimal TWP options before a decision can be made on which of the two alternative schemes should be recommended for implementation.

6.8 Review scheme component sizes and configuration

The objective of the TWP feasibility study was to identify the most feasible scheme to supply a nominal volume of 15 m^3/s (473 million m^3/annum) to the Vaal River System. This objective originated from the augmentation requirements that were determined in 1999, and the available capacity of the existing Thukela-Vaal scheme to convey water to the Vaal River System. The 1999 water requirement projection of the Vaal River System were higher compared to the scenarios presented in this document and required larger augmentation support.

The augmentation requirement for **Scenario B** in the year 2030 of 215 million m^3/annum, is substantially lower than the 473 million m^3/annum target that was use for the optimisation of the scheme configuration in the TWP feasibility study. Therefore, the concern is that the optimal configuration for a target of 473 million m^3/annum is not necessarily the optimal configuration for a target augmentation volume of 215 million m^3/annum.
In addition, comparing an optimised LHFP option with a sub-optimal TWP configuration would not provide a fair and realistic comparison.

It is therefore proposed that the TWP option should be re-evaluated to determine the most optimal configuration and size for a target augmentation volume of 215 million m^3/annum.
The re-evaluation work could be the function of either the Directorate: Option Analysis or the Directorate: National Water Resource Planning.

6.9 Review reconciliation options based on results from reserve study

The Comprehensive Reserve Determination Study (commissioned by the DWAF Directorate: RDM in August 2006) will produce Ecological Water Requirement Scenarios, and the implication thereof on the reconciliation options will have to be determined and evaluated.

6.10 Strategy implementation monitoring

At the Steering Committee Meeting held on 29 March 2006, it was recommended that a committee be formed to oversee the implementation of the reconciliation strategies. Broadly, the function of the committee will be to continuously monitor the water balance situation of the Vaal River System, and advise the responsible institutions on whether or not the objectives of the strategies are being achieved.

7 Lessons Learned

The formulation of the reconciliation strategy for the Vaal River System has shown that there are key activities or processes that are necessary to develop a strategy, namely:

- Integration of technical assessments across institutional boundaries is a prerequisite for the development of a coherent strategy. This was illustrated by the coordination of activities in separate studies that were executed in parallel by different DWAF Directorates.
- In combining the stakeholder engagement processes of the three studies (see the introductory section), through cross representation of official and study team members on the different committees, made it possible to effectively communicate a synthesised message to the stakeholder. This approach also helped to direct and focus stakeholder comments and suggestions since they were informed of the activities of all of the studies at each engagement event.
- The quantification (updating) of the variables influencing the water balance and the assessments of respective scenarios made it possible to pinpoint the areas where further water resource management interventions are required. This was carried out without having the final data available from parallel studies (e.g. only preliminary results were available from the water use validation), however, the available information was of sufficient confidence to point to the problem of unlawful water use.
- The task to compile the water requirement scenarios and, more specifically, the configuration of the Water Requirement and Return Flow Model identified the need for processes to improve the integration of information (processes and data) between the water resources and water services sectors. The integration of the respective "needs" and "products" of the two sectors through the development of an integrated business process analysis is recommended.
- The development of the reconciliation strategy in two stages, provided the benefit that the areas of focus could be identified during the first stage, which guides the efforts for the second stage to be focussing on the pertinent management interventions.
- Consideration should be given to establish a central database containing all the data required for compiling a reconciliation strategy. This will reduce the time and cost that have to be spent in data collection and collation with the benefit that more resources can be allocated to assessments in support of the formulation of the strategy.

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