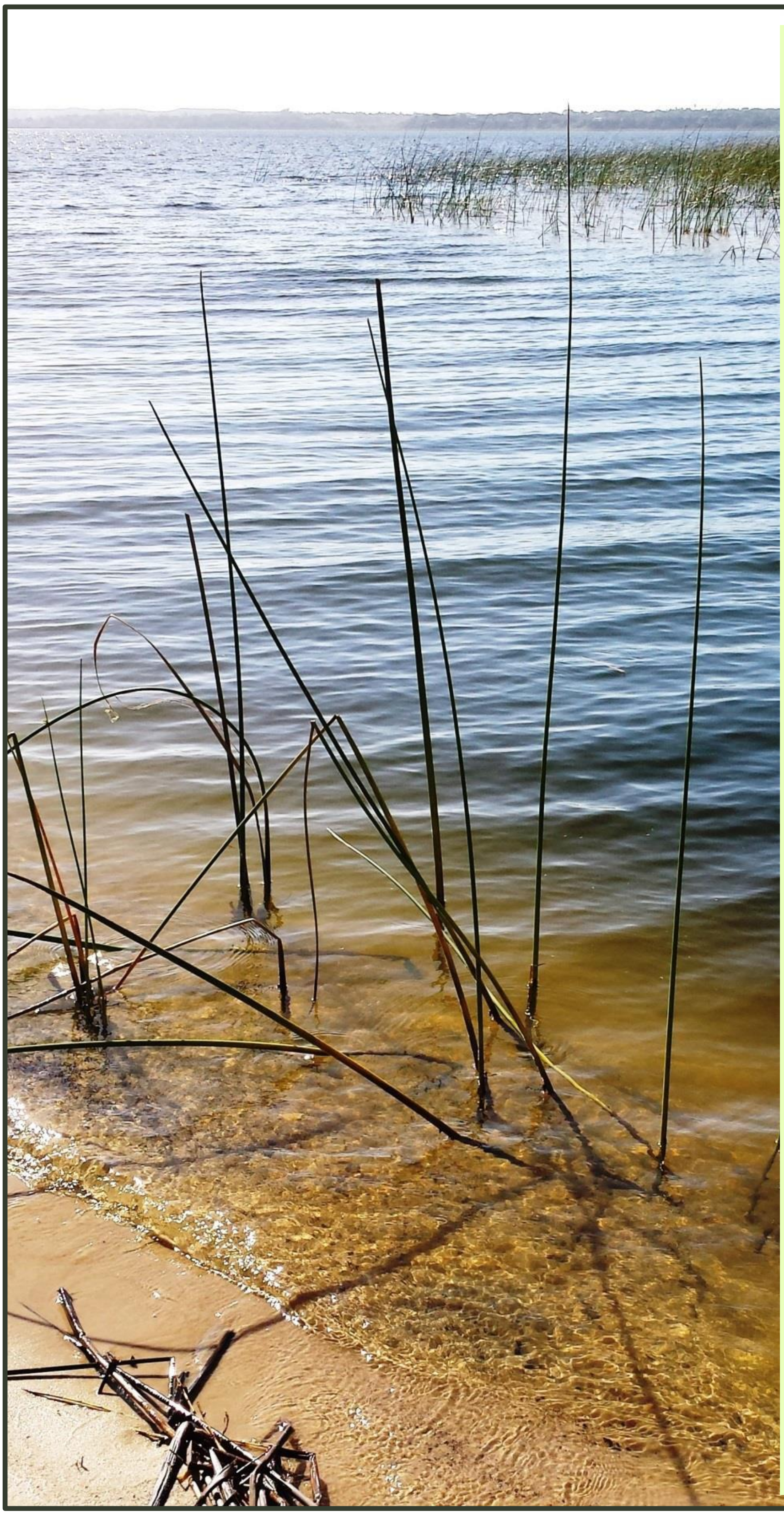



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Water Balance Report

Water Reconciliation Strategy for
Richards Bay and Surrounding Towns

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DEPARTMENT OF WATER AND SANITATION

Directorate: National Water Resources Planning

Water Reconciliation Strategy for Richards Bay and Surrounding Towns

YIELD ANALYSIS REPORT

April 2015

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WATER RECONCILIATION STRATEGY FOR RICHARDS BAY AND SURROUNDING TOWNS

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Executive summary

Background

An assessment of the water availability and balance for the study area was undertaken to provide a summary of the current resources and water available to the Mhlathuze Local Municipality. The focus is on the water supply to Richards Bay and its industries but an overview of the Mhlathuze catchment water resources is also provided.

A review of the previous water resource modelling studies undertaken for the Mhlatuze catchment was done. The most recent of such studies was the Mhlatuze Catchment - Modelling Support for Licensing Scenarios (DWA, 2012)[(3)] which was a follow-on study from the Mhlathuze Water Availability Assessment Study (MWAAS) (DWAF, 2009)[2], and the main objective was to provide technical support to its Regional Office in the application of the model developed during the MWAAS to assist with water reallocation, provision of analytical support in the management of the water resources and also to offer a support function in the water use licence evaluation process. The MWAAS was a comprehensive water resources assessment for the purpose of assessing the available water resources in support of the process to license water use in the catchment. The study focussed on a technical water resource analysis of the Mhlatuze, Amatikulu and Mlalazi river basins. A detailed surface water hydrology assessment was undertaken and a detailed Water Resources Yield Model (WRYM) was configured for the catchment.

The WRYM that was configured in the MWAAS and the subsequent Licensing Support Study was used in the current study as the most representative configuration of the Mhlathuze catchment to date.

Water Requirements

The 2013 water requirements and allocations for the Richards Bay Water Supply System (WSS) are described in detail in the *Water Requirements Report (*DWS, 2014), a supporting report for this study.

A breakdown of the current (2013) water requirements of each sector is as follows:

- The total estimated water use for the urban and industrial water use sectors for 2013 is 95.94 million m^3/a.
- The allocated water requirement for urban and industrial users is 127.84 million m^3/a.
- The maximum allocated irrigation volume for the Mhlatuze catchment is 125 million m^3/a.
- While recent historical water use for irrigation is not available, indications are that recent actual use is very low, probably in the region of 50% of allocations in dry years, and significantly below that in wet or normal rainfall years.

The WRYM was updated with the 2013 water use requirements and allocations for the users in the Richards Bay WSS. The modelled volume of water supplied to users is summarised below.

Table E1: Allocated volumes

Water use sector	*Allocated volume (million m^3/a)*	*Modelled volume (million m^3/a)*	*% Supplied*
Bulk Industry	90.96	90.02	99%
Urban	36.87	35.31	96%
Irrigation	125.00	94.62	A portion of the irrigation requirement is satisfied by rainfall
Total volume	**252.83**	**219.95**	

Table E2: Estimated 2013 water use

Water use sector	*2013 Required volume (million m^3/a)*	*Modelled volume (million m^3/a)*	*% Supplied*
Bulk Industry	55.94	55.43	99%
Urban	40.00	39.26	98%
Irrigation	*125.00*	88.49	A portion of the irrigation requirement is satisfied by rainfall
Total volume	**220.94**	**183.18**	

Water Availability

The estimate of water availability in the current study for the Mhlathuze catchment is 195.1 million m^3/a. This is based on the historical firm yield of the water supply system at the Mhlathuze Weir with support from Goedertrouw Dam, plus the yield of the natural lakes (with no demands or additional support), plus an estimated volume for return flows and groundwater contribution in the catchment.

Water Balance

The interim water balance for the Mhlathuze water supply system is presented in the table below. The modelled volumes supplied to the users for the 2013 water requirements is 183.9 million m^3/a. With an estimated volume of 195.1 million m^3/a as available water based on the current system constraints, a small surplus of 11.2 million m^3/a is possibly available.

Table E3: 2013 Water Balance

Water component	*Volume (million m^3/a)*
Available water	**195.1**
Total water requirement:	**183.9**
Irrigation	88.5
Urban	40.0
Industrial	55.4
Balance	**11.2**

Contents

Tables

Acronyms

DEA	Department of Environment Affairs
DWS	Department of Water & Sanitation
EFR	Estuarine Flow Requirement
ESIA	Environmental and Social Impact Assessment
EWR	Ecological Water Requirement
GDP	Gross Domestic Product
IDZ	Industrial Development Zone
IFR	Instream Flow Requirements
MAP	Mean Annual Precipitation
NGO	Non-Government Organisation
NRW	Non Revenue Water
RBCT	Richards Bay Coal Terminal
RBM	Richards Bay Minerals
SFRA	Streamflow Reduction Activities
WAAS	Water Availability Assessment Study
WC/WDM	Water Conservation and Water Demand Management
WRPM	Water Resources Planning Model
WRYM	Water Resources Yield Model
WSS	Water Supply System
WSSA	Water and Sanitation Services South Africa
WTW	Water Treatment Works
WWTW	Wastewater Treatment Works

1 Water Availability and Balance

1.1 Introduction

Richards Bay is the economic centre of the uMhlathuze Local Municipality which further comprises Empangeni, Ngwelezane, Nseleni, eSikhaleni and a number of rural villages. Richards Bay is one of the strategic economic hubs of the country. Though the water resources available to the uMhlathuze Municipality are currently sufficient to cater for the existing requirements, should anticipated growth and industrial development materialise the current water sources are likely to come under stress.

The objective of the study is to develop a strategy to ensure adequate and sustainable reconciliation of future water requirements within the uMhlathuze Local Municipality with potential supply up to 2040, especially that of Richards Bay / Empangeni, their significant industries, as well as the smaller towns and potential external users that may be supplied with water from the system in future.

The purpose of this section is to describe the current water availability and balance of the Richards Bay water supply system (WSS) and surrounding areas using the latest available water use information which has been sourced as part of this study and which is described in detail in a supporting *Water Requirements Report* (Department of Water and Sanitation (DWS), 2014)[1].

1.2 Methodology and assumptions

A review of the previous water resource modelling studies undertaken for the Mhlathuze catchment was done. The Mhlathuze Water Availability Assessment Study (MWAAS) (DWAF, 2009)[2] was a comprehensive water resources assessment for the purpose of assessing the available water resources in support of the process to license water use in the catchment. The study focussed on a technical water resource analysis of the Mhlathuze, Amatikulu and Mlalazi river basins. A detailed surface water hydrology assessment was undertaken and a detailed Water Resources Yield Model (WRYM) was configured for the catchment.

The WRYM is a tool used to analyse the water resource system for a variety of operating rules and to determine the system's short term and long term yield or resource capability. The purpose of a yield analysis is to assess the total long- and short-term yield at a particular point in a water resource system at a fixed selected development level and set of system operating rules. The yield of a system can be determined based either on a historical yield analysis, in which case the yield is typically expressed as a historical firm yield, or based on a stochastic yield analysis, in which case assurance of supply (or risk of non-supply) may be determined for a variety of yields. A water resources system is configured in the model using a combination of nodes and channels that represent physical features and flow paths in the system. A system diagram is created that shows the connectivity between the different features and describes the nature of the relationship between components in the system. Features that are included are reservoirs, junction nodes, flow channels and water users.

The "*Mhlathuze Catchment – Modelling Support for Licencing Scenarios*" project (DWA, 2012)[3] was a follow on study from the MWAAS and its main objective was to provide support to the DWS Regional Office to assist with water reallocation in the catchment, to provide analytical support in the management of the water resources and to perform a support function in the evaluation of water use licenses using the model developed during the MWAAS.

The MWAAS was completed in preparation for the compulsory licencing process, producing a detailed water resource model for the Mhlathuze, Mlalazi and Amatikulu river systems which was used for the analysis in the licencing study. The final configuration of the WRYM used in the MWAAS was further refined in the "*Mhlathuze Catchment – Modelling Support for Licencing Scenarios*" study[3] and it was this refined configuration that was used in the current study for the analysis of water availability and assessment of scenarios.

During the Inception Phase of the current study and as part of the initial evaluation of the previous studies for this task, it was concluded that no changes would be made to the MWAAS hydrology and land use information contained in the model configuration. Because the MWAAS undertook a comprehensive evaluation of these aspects, it was not considered necessary to update them in this study since it was not part of the original scope of work for this assessment, and it would not be possible to complete the task to the same level of detail as was done previously, thereby not adding any significant additional value to the current analysis. The model was therefore updated only with the latest estimates for industrial and urban use for the Richards Bay WSS as reported in the *Water Requirements Report.* In addition the irrigation allocations were amended according to the latest available information. Irrigation water use is modelled as a time varying demand in the WRYM as opposed to a fixed monthly demand. This means that the crop demand is supplied first by rainfall and thereafter by abstraction from the river or from storage up to the maximum allocation allowed.

Table 1-1 provides a comparison of the industrial and urban requirements from the "*Mhlathuze Catchment – Modelling Support for Licencing Scenarios*" study and the current study. The table is an excerpt from the final report of that study (DWA, 2012) to which the 2013 water use and allocated use from the current study have been added. It also identifies the WRYM channel numbers that represent the flow paths of specific water users which is a useful reference for the modeller for the purpose of revising the water use figures in the model for the current study. In cases where a water user is located outside the Richards Bay WSS, the previous water use volume modelled has been retained. It is noted that the 2013 water use for industrial and urban requirements is substantially less than that modelled in the previous study.

Table 1-1 | Industrial and urban water requirements summary

Source: *"Mhlathuze Catchment – Modelling Support for Licencing Scenarios"* Table 4-6				Source: *"Water Reconciliation Strategy for Richards Bay and Surrounding Towns. Water Requirements Report"* Table 2-11			
Source	**WRYM channel no.**	**Detail**	**Call for licences (million m^3/a)**	**Description**	**2013 water use**	**2013 Allocated water use**	**Source (Recon)**
INDUSTRIAL REQUIREMENTS							
Nsezi	**127**	MW to Mondi Kraft Rich Bay	54.750	Mondi RB	23.610	32.850	Mhlathuze Water
Nhla, Nsezi	**146**	MW to RBM (ponds)	7.425	RBM Nhlabane+RBM Mfolozi+ RBM Nsezi	12.950	23.741[1]	Zulti ponds - Lake Nhlabane + supplement from Mfolozi
Mfol, Nhla, Nsezi, Sok	**146**	RBM Zulti north ponds	15.575				
Nhla, Nsezi	**323**	MW to RBM (smelter)	9.000	RBM (smelter)	2.380	6.259[1]	Lake Nsezi (smelter)
W12F	**635**	MW to Ticor	9.490	Tronox	5.300	11.480	Mhlathuze Weir via Nsezi WTW to Hillendale only (Fairbreeze for future scenario)
Mzin, Nsezi	**167**	RB ind	0.000	Foskor (clarified) + RBCT + Bayside + Hillside	5.790	7.300	Foskor clarified: Nsezi WTW
Nsezi	**638**	MW to FOSCOR potable	4.964	Foskor potable	2.970	4.960	Mzingazi WTW (potable)
W12F	**635**	MW to Mondi packaging Felixton	3.150	Mpact (Mondi Felixton)	2.220	2.480	Abstraction from Mhlathuze River - return flow to river
W12F	**273**	Tongaat Hulett	1.888	Tongaat Hulett	0.710	1.890	Abstraction from Mhlathuze River - return flow to river
		Total Industry	**106.242**	**Total Industry**	**55.94**	**90.96**	
URBAN REQUIREMENTS							
Nsezi	**637**	MW to Empangeni urban	6.570	Empangeni (urban)	7.79	13.510	Nsezi WTW
Mzin, Nsezi	**167**	RB urban	24.180	RB Urban	14.240	9.130	Lake Mzingazi (Mzingazi WTW)
Mzin, Nsezi	**167**	MW to City of Mhlathuze for RB	7.300				

Source: *"Mhlathuze Catchment – Modelling Support for Licencing Scenarios"* Table 4-6				Source: *"Water Reconciliation Strategy for Richards Bay and Surrounding Towns. Water Requirements Report"* Table 2-11			
Source	**WRYM channel no.**	**Detail**	**Call for licences (million m^3/a)**	**Description**	**2013 water use**	**2013 Allocated water use**	**Source (Recon)**
Cubhu	**135**	Felixton	1.444	eSikhaleni (+Felixton +Vulindlela)	11.160	11.320	Lake Cubhu (eSikhaleni WTW)
Cubhu	**135**	Vulindlela urban	6.696				Lake Cubhu (eSikhaleni WTW)
W12F, Cubhu	**636**	MW to Esikhaweni	5.475	eSikhaleni (+Felixton+Vulindlela)	-	-	Lake Cubhu (eSikhaleni WTW) (Combined with channel 135)
W12H	**118**	Nseleni WTW	0.000	Nseleni (urban)	4.280	0.000	Nseleni WTW
W12E	**89**	Ngwelezane urban	2.920	Ngwelezane urban	2.540	2.920	Mhlathuze River (Ngwelezane WTW)
		Total Urban	**54.585**	**Total Urban**	**40.00**	**36.87**	
		Total Industry + Urban	**160.827**	**Total Industry + Urban**	**95.94**	**127.84**	
OTHERS							
W12A	**5**	Nkandla urban	0.269	*Nkandla urban*	*0.269*	*0.269*	*Use previous volumes*
Goed	**106**	Mtonjanene rural	0.526	*Mtonjanene rural*	*0.526*	*0.526*	*Use previous volumes*
Goed	**106**	kwaHlokohloko rural	0.329	*kwaHlokohloko rural*	*0.329*	*0.329*	*Use previous volumes*
	301	Ging / Eshowe / Mtunzini	1.200	*Ging / Eshowe / Mtunzini*	*1.200*	*1.200*	*Use previous volumes*
Nsezi	**637**	Umhlat Loc Mun, Lake Nsezi	1.768	*Umhlat Loc Mun, Lake Nsezi*	*1.768*	*1.768*	*Use previous volumes*

Notes:

(1) RBM – The total maximum allocation is 30 million m^3/a even though the sum of allocations from RBM's individual sources are greater than this. Presently, there is no supply from the Mfolozi River. The allocation has been adjusted to be the difference between the Lake Nhlabane maximum allocation and 30 million m^3/a which is the maximum allocation allowed from all sources. This is based on the assumption that abstraction from Lake Nsezi is more expensive. As a result, there is a smaller requirement from this source and Lake Nhlabane is the preferred source.

1.3 Water Requirements

The Richards Bay system water requirements are described in detail in the *Water Requirements Report* (DWS, 2014), a supporting report for this study. A breakdown of the current water requirements of each sector is summarised in Appendix A of the report.

The total estimated water use for 2013 for the Richards Bay WSS was 95.94 million m^3/a comprising urban and bulk industrial water use sectors. The maximum allocated irrigation volume for the Mhlatuze catchment is 125 million m^3/a and the ecological water requirements are summarised in Section 1.3.3.

1.3.1 Urban and Bulk industrial

The bulk industrial water use for 2013 has been estimated to be 55.94 million m^3/a, while the maximum allocated water use for bulk industry is 90.96 million m^3/a.

The urban water use for 2013 has been estimated to be 40.00 million m^3/a, while the allocated water use for urban requirements is 36.87 million m^3/a.

1.3.2 Irrigation

The DWS is currently recalculating the final schedules for irrigation use, and indications are that the irrigation allocation towards the end of compulsory licensing will be in the order of 121.1 million m^3/a.

Once this phase of the compulsory licensing process is complete, there will be an additional volume of water set aside for future small irrigation development. When this volume has been allocated, it is doubted whether any additional water will be available for commercial irrigation. It is anticipated that small volumes may still be allocated to resource-poor farmers (likely sugar cane irrigation and community forestry) in future. The precise volume set aside for future small irrigation development is not certain, but it is expected that it may be up to approximately 5 million m^3/a.

The value used in this study for the final allocation volume for irrigation, including a portion of the volume set aside for future small irrigation development, is 125 million m^3/a. This allows for small changes in allocations of existing irrigation, should it become necessary, as well as for some allocation to resource-poor farmers.

1.3.3 Ecological Water Requirements

DWS RDM produced a new set of River Quantity ecological water requirements (EWRs) in 2012 which superseded all previous EWRs that had been used. This preliminary Reserve has been approved by DWS and therefore has a legal status. Table 1-2 presents an extract summary from the EWR document which was incorporated into the WRYM configuration.

Table 1-2 | Preliminary determination of the Reserve for Water Quantity

Quaternary Catchment	Water resource	Ecological Reserve (%) NMAR	Ecological Reserve Volume (Mm^3)	Basic Human Needs (%NAMR)	*Total Reserve (%)	NMAR (Mm^3)
W12A	***Mhlatuze River: Estimated from IFR site 1	38.1	24.7	0.40	38.5	64.8
W12B	**Mhlatuze River: IFR site 1	30.5	54.3	0.06	30.6	156.7
W12C	***Mhlatuze River: Estimated from IFR site 2	26.3	13.4	0.16	26.4	50.8
W12D	**Mhlatuze River: IFR site 3	26.3	70.8	0.14	26.4	195.2

Quaternary Catchment	Water resource	Ecological Reserve (%) NMAR	Ecological Reserve Volume (Mm^3)	Basic Human Needs (%NAMR)	*Total Reserve (%)	NMAR (Mm^3)
W12D	**Mhlatuze River: IFR site 2	26.6	81.8	0.10	26.7	265.8
W12E	**Mhlatuze River: IFR site 4	11.4	40.3	0.11	11.5	278.1
W12F	**Mhlatuze River: IFR site 4	11.4	40.3	0.23	11.6	332.4
W12G	***Nseleni River: Estimated from IFR site 1	38.0	10.2	0.34	38.3	26.8
W12H	***Nseleni River: Estimated from IFR site 4	26.1	22.7	0.63	26.7	87.2

**This amount is the sum of ecological reserve and basic human needs.*

***Indicates the Original 2001 IFR Sites.*

****New Hydrological Nodes to which IFR results estimated to.*

The WRYM for the Mhlathuze catchment has been configured such that all EWRs are satisfied as a priority. The ecological component of the Reserve is given the second-highest priority, after the Basic Human Needs Reserve component, which is estimated as 25l/capita/day for all inhabitants of the catchment[4].

During final modelling undertaken to support compulsory licensing, some cases were found where the revised river EWRs required more water than was naturally available. These cases were adjusted such that the requirement was decreased to be equal to the natural flow.

The MWAAS study[2] further includes estimates for the estuarine flow requirements (EFR) for the quaternary catchments within the Mhlathuze River Catchment, obtained from the Mhlathuze Operating Rules and Future Phasing study[5] and summarised in Table 1-3.

Table 1-3 | Ecological Requirement Reserved for lakes

Lake	Ecological requirement (million m^3/annum)
Lake Nsezi	2.9
Lake Mzingazi	4.5
Lake Cubhu	1.5
Lake Nhlabane	14.3
TOTAL	**23.2**

It is noted that the figure for Lake Nhlabane in Table 1-3 is misleading, because the transfer from the Mfolozi River is included in the system modelling in support of the Reserve determination, as noted in the discussion of scenarios. Some of these stated Lake Reserves are larger than the latest estimated sustainable yields of these lakes, and must be treated with caution.

1.3.4 Land use

As stated in Section 1.2, no changes were made to the MWAAS land use information for this assessment. The estimated water use for streamflow reduction activities including invasive alien vegetation and dryland sugar cane from the MWAAS was retained. Commercial forestry is a licenced streamflow reduction activity and was assessed under the the "*Mhlathuze Catchment – Modelling Support for Licencing Scenarios*" study. The registered area of forestry under the Call for Licences was 50 km^2 with a corresponding estimated volume of approximately 52 million m^3/a. However, the MWAAS captured an area of 68 km^2 using aerial photography with a corresponding water use of 69 million m^3/a. As the latter is a more conservative figure, it was used as the representative current water use by commercial forestry (DWA, 2012). This figure has therefore been retained for the current analysis.

1.3.5 Modelling results

The following sections present the modelled volumes of water supplied to the industrial, urban and irrigation users in the study catchment for their allocated volumes as well as the estimated water use for 2013. The purpose of presenting these results is first to check that the model has been correctly updated with the water requirements for the current study, and second to provide a baseline indication of how well the system can satisfy the demands on the resources based on our current understanding of the operation of the system. It can also then be used to test the impact of possible future interventions and a range of scenarios which is a separate deliverable for this study.

It is important to note that the Mfolozi transfer is not in operation for these simulations.

1.3.5.1 Allocated water use

The modelled volumes of water supplied to individual water users are presented in Table 1-4. A summary of total modelled volume of water supplied to each water use sector for the allocated water use scenario is shown in Table 1-5.

Table 1-4 | Individual users' allocated water requirements and modelled volume

Supply Sector	*User*	Allocation		Modelled volume	
		Annual (million m^3/a)	*Daily (Ml/d)*	*Annual (million m^3/a)*	*% supplied*
Industry	Mondi Richards Bay	32.85	90.00	32.12	98%
	RBM - Total	**30.00**	**82.19**	**29.81**	**99%**
	RBM - Nhlabane	23.73	65.00	23.57	99%
	RBM - uMfolozi	78.84	216.00	-	-
	RBM - Nsezi	18.25	50.00	6.24	34%
	Tronox - Total	**11.48**	**31.46**	**11.47**	**100%**
	Tronox - Hillendale	11.48	31.46	11.47	100%
	Tronox - potable	-	0.00	0.00	-
	Foskor - Total	**11.17**	**30.60**	**11.16**	**100%**
	Foskor - clarified	6.21	17.00	6.20	100%
	Foskor - potable	4.96	13.60	4.96	100%
	Mpact	2.48	6.79	2.48	100%
	Tongaat Hulett	1.89	5.17	1.89	100%
	Bayside - Total	**0.34**	**0.94**	**0.34**	**100%**
	Bayside - raw	0.34	0.94	0.34	100%
	Bayside - potable	0.00	0.00	0.00	-
	Hillside	0.75	2.05	0.75	100%
	RBCT	0.00	0.00	0.00	-

Supply Sector	*User*	Allocation		Modelled volume	
		Annual (million m³/a)	*Daily (Ml/d)*	*Annual (million m³/a)*	*% supplied*
	Total	**90.96**	**249.21**	**90.02**	**99%**
Urban	Empangeni	13.51	37.00	13.44	99%
	Richards Bay	9.13	25.00	9.13	100%
	eSikhaleni	11.32	31.00	9.96	88%
	Nseleni	0.00	0.00	0.00	-
	Ngwelezane	2.92	8.00	2.79	96%
	Total	**36.87**	**101.00**	**35.32**	**96%**
	GRAND TOTAL	**127.83**	**350.21**	**125.34**	**98%**

Table 1-5 | Water use sectors: allocated water requirements and modelled volume

Water use sector	*Demand: Allocation (million m³/a)*	*Modelled supply (million m³/a)*	*% Supplied in model*
Bulk Industry	90.96	90.02	99%
Urban	36.87	35.32	96%
Irrigation	125.00	94.62	A portion of the irrigation requirement is satisfied by rainfall
Total volume	**252.83**	**219.96**	

1.3.5.2 Current (2013) water use

The modelled volumes of water supplied to individual industrial and urban water users are presented in Table 1-6 and the modelled volume supplied to irrigation schemes is presented in Table 1-7. A summary of the modelled volume of water supplied to each water use sector for the 2013 water use scenario is shown in Table 1-8.

Table 1-6 | Individual users 2013 water requirements and modelled volume

Supply Sector	*User*	Current (2013) usage		Modelled Volume	
		Annual (million m³/a)	*Daily (Ml/d)*	*Annual (million m³/a)*	*% supplied*
Industry	Mondi Richards Bay	23.61	64.70	23.18	98%
	RBM - Total	**15.34**	**42.02**	**15.31**	100%
	RBM - Nhlabane	12.95	35.49	12.94	100%
	RBM - uMfolozi	0.00	0.01		
	RBM - Nsezi	2.38	6.53	2.37	100%
	Tronox - Total	**5.30**	**14.52**	**5.29**	100%
	Tronox - Hillendale	3.75	10.28	3.75	100%

Supply Sector	User	Current (2013) usage		Modelled Volume	
		Annual (million m^3/a)	*Daily (Ml/d)*	*Annual (million m^3/a)*	*% supplied*
	Tronox - potable	1.55	4.24	1.55	100%
	Foskor - Total	**7.09**	**19.42**	**7.09**	100%
	Foskor - clarified	4.12	11.28	4.12	100%
	Foskor - potable	2.97	8.14	2.97	100%
	Mpact	2.22	6.07	2.22	100%
	Tongaat Hulett	0.71	1.95	0.69	97%
	Bayside - Total	**0.52**	**1.44**	**0.52**	100%
	Bayside - raw	0.34	0.94	0.34	100%
	Bayside - potable	0.18	0.50	0.18	100%
	Hillside	0.72	1.97	0.72	100%
	RBCT	0.43	1.19	0.43	100%
	Total Industry	**55.94**	**153.27**	**55.45**	**99%**
Urban	Empangeni	7.79	21.35	7.79	100%
	Richards Bay	14.24	39.02	14.17	100%
	eSikhaleni	11.16	30.56	10.75	96%
	Nseleni	4.28	11.71	4.02	-
	Ngwelezane	2.54	6.95	2.47	97%
	Total Urban	**40.00**	**109.59**	**39.20**	**98%**
	GRAND TOTAL	**95.94**	**262.86**	**94.65**	**99%**

Table 1-7 | Irrigators' allocated water requirements and modelled volume supplied

Irrigators as represented in the WRYM	*Total area (ha)*	*Allocated volume (latest from DWS) (million m^3/a)*	*Volume supplied from WSS (million m^3/a)*
Nkwaleni	4592.60	57.09	44.13
Mfuli	575.80	5.53	4.86
Heatonville	3227.10	41.45	27.87
Lower Mhlathuze	1037.90	8.03	5.60
Other irrigators (sub-total):	2658.10	8.97	6.00
• *Inkasa sugar*	*511.00*	*1.36*	*1.23*
• *Barn wans sax sugar*	*75.60*	*0.22*	*0.21*
• *Diepkloof*	*0.00*	*0.00*	*0.00*
• *Nooitgedacht*	*30.00*	*0.19*	*0.18*
• *W12H*	*2031.50*	*7.11*	*4.33*
• *Mankuzuka*	*10.00*	*0.08*	*0.05*
Total	**12091.50**	**125.00**	**88.49**

Table 1-8 | Water use sectors: 2013 water requirements and volume supplied

Water use sector	*Demand: 2013 Requirement (million m³/a)*	*Modelled supply (million m³/a)*	*% Supplied*
Bulk Industry	55.94	55.43	99%
Urban	40.00	39.20	98%
Irrigation	*125.00*	88.49	A portion of the irrigation requirement is satisfied by rainfall
Total volume	**220.94**	**183.18**	

1.4 Water Availability

1.4.1 Previous studies

The approach to assessing the system yield in the MWAAS is described briefly below, for a more detailed description the reader is referred to Chapter 5 of the MWAAS Systems Analysis Report (DWAF, 2009). Both the firm yield and the average yield were determined with irrigation modelled both as a time varying demand and as a fixed seasonal demand. The firm yield is defined as the volume of water that can be abstracted (target draft) at a point in the system without any annual failures. While the average yield is the average annual volume of water that can be supplied over a period of time for a required target draft regardless of whether there are failures or not.

Urban and industrial demands were satisfied first and irrigation second. If failures to urban and industrial users occurred, then supply to irrigation was reduced until urban and industrial demands were satisfied. The sum of the urban, industrial and irrigation supply, as well as the residual water available at the Mhlathuze Weir, was defined as the yield of the system. Based on this approach, the historical firm yield of the Mhlathuze system for two scenarios of irrigation was determined, as well as a scenario where irrigation areas were reduced to zero, and is presented in

Table 1-9 (DWA, 2009).

One main reason for differences in yield results compared to previous studies is that irrigation is modelled as a time varying demand (irrigation block) rather than a fixed seasonal demand as in previous studies. MWAAS modelled both scenarios and obtained a lower yield when using a time-varying demand for irrigation. The prevailing rainfall conditions have a much greater effect on the volume of water that needs to be supplied from the river or from storage and as a result, the difference in yield can be attributed to the increased irrigation requirement during dry periods, causing the reservoir to be drawn down more severely and thereby reducing the system yield for the firm yield analysis.

Table 1-9 | Historic firm yield of Mhlathuze system from MWAAS (DWA, 2009)

Irrigation scenario	*Urban/Industrial water supply (million m^3/a)*	*Irrigation water supply (million m^3/a)*	*Direct supply from Mhlathuze Weir (million m^3/a)*	*Combined total water supply (million m^3/a)*
"1) Full irrigation area with 'capping' equivalent to observed water use and time varying demand"	112.0	100.3	2.0	214.3
"3) Full irrigation area with 'capping' equivalent to observed water use and fixed seasonal demand"	112.0	105.0	28.0	245.0
"4) Irrigation area reduced to zero"	112.0	0.0	124.0	236.0

The "*Mhlathuze Catchment – Modelling Support for Licencing Scenarios*" study did not calculate yield as such, but looked at the overall balance of the system by assessing the percentage water supplied to different water use sectors for various scenarios. The differences in yield obtained as a result of the revised irrigation module were therefore not that noticeable.

1.4.2 Yield of individual storages

In the current assessment, the historical firm yield of individual storages has been carried out for comparison with the MWAAS results shown in Table 1-10 (the yields obtained in the MORFP study are also included for reference purposes). The water supply network was also adjusted for the calculation of individual yield so that each storage body was isolated from local inflows, transfers and demands, which was the same approach taken in the MWAAS. The study team has noted slight differences between the yields which were not anticipated despite using the same approach as well as the same hydrology and land use information as the MWAAS. This can most likely be attributed to slight changes in the model configuration which took place during the *Mhlathuze Catchment – Modelling Support for Licencing Scenarios* and which is the configuration from which the current study is based.

Table 1-10 | Historical firm yields of individual lake storages

Lake/Reservoir	*MORFP HFY (million m^3/a)*	*MWAAS HFY (million m^3/a)*	*Current study HFY (million m^3/a)*
Goedertrouw Dam excl. Thukela transfer	70.8	58	51.5
Goedertrouw Dam incl. Thukela transfer	Not modelled	Not modelled	84.5
Lake Nsezi	13.9	5.7	6.6
Lake Mzingazi	10.8	8.2	10.5
Lake Cubhu	5.3	0.3	0.4
Lake Nhlabane: with support from Mfolozi	30.7	32.7	34.5
Lake Nhlabane: with no support from Mfolozi	Not modelled	Not modelled	7.9
Total yield from natural lakes (with support from Mfolozi)	*60.7*	*46.9*	*52.0*
Total yield from natural lakes (with no support from Mfolozi)	*Not modelled*	*Not modelled*	*25.4*

1.4.3 Concerns relating to abstraction from lakes

The confidence in the current estimated WSS lake yields is very low, as only the surface water component of these yields has historically been taken into account in the modelling. Groundwater contributions to the lakes could not be quantified with an acceptable level of confidence to be included in the lakes' yields estimation (MORFP study). There is a concern that abstractions from the lakes in the strategy area are "*significantly in excess of their sustainable yields*".

This is an important issue that needs to be addressed, as documented in the *Water Requirements Report*. It is recommended that additional attention should be paid in order to improve this assessment in future, by monitoring and quantifying the groundwater contribution, as well as the interaction between groundwater and surface water. Yields for the lakes can then be determined at an acceptable level of confidence.

Richards Bay Minerals has undertaken an evaluation of the sustainable yield of Lake Nhlabane (*Nhalabane Sustainability Assessment*), and has concluded that the sustainable abstraction from the lake has dropped to 30 000 m^3/d as a result of land use changes, compared to RBM's demand of 29,000m^3/day. This equates to a yield of 10.95 m^3/a. Based on the increasing trend in streamflow reduction, it is estimated that this may within another 5 years drop to 20 000 m^3/d, unless there is a substantial increase in rainfall or the land use trends change.

1.4.4 Current study yield estimates

An initial estimate of the available water in the Mhlathuze system was done by switching off all the irrigation, urban and industrial demands. A yield channel with a fixed seasonal demand was placed at the Mhlathuze Weir and the historical firm yield was determined. The resultant yield is 122.1 million m^3/a which represents the yield available from Goedertrouw Dam and at the Mhlathuze Weir. The individual yields of the lakes were added to this yield as well as an estimate of catchment return flows and groundwater contribution. The transfers from the Thukela and the Mfolozi rivers were incorporated in two ways. This was firstly done by calculating the yield *excluding* the transfers and adding the estimated volume of each transfer outside of the model. Second, this was done by calculating the yield by switching on the transfers and thereby integrating them into the system. The results are shown in Table 1-11. The available water using the second approach is slightly higher which highlights the benefit of storage to the yield of the system.

Table 1-11 | Summary of water availability in the Mhlathuze catchment

Source	***HFY 1[(a)]: Estimated contribution to system yield (million m^3/a)***	***HFY 2[(b)]: Estimated contribution to system yield (million m^3/a)***
Thukela transfer	34	*(34)*
Mfolozi transfer	18	*(18)*
Yield from natural lakes	25.4	52
Return flow[(c)]	10	10
Goedertrouw Dam plus run-of-river yield at Mhlathuze Weir	86.6	122.1
Total (Surface water)	**174.0**	**184.1**
Estimated groundwater contribution[(d)]	11	11
Total (All sources)	**185.0**	**195.1**

Notes:

[(a)] *The yield calculation assumes that the transfer from Thukela and Mfolozi are not in operation and the* *estimated transfer volume is simply added to the total yield for the system after the yield is determined in the WRYM.*

[(b)] *The yield calculation assumes that the transfer from Thukela and Mfolozi are in operation and is integrated to the system, resulting in a higher net yield from the respective sources i.e. Goedertrouw for Thukela and Lake Nhlabane for Mfolozi*

[(c)] *Estimated return flows from the MORFP Study (DWAF, 2001)*

[(d)] *Estimated groundwater contribution from MORFP Study (DWAF, 2001)*

Further analysis was undertaken to try to gain a better understanding of the integrated system, including the effects that the natural lakes have on the system yield. This was achieved by using a slightly different approach, which is described below. In order to compare to the yield results obtained in the MWAAS, it was necessary to determine the supply to the urban and industrial users which represented the firm yield i.e. no failures in supply. It was also necessary to determine the net supply to irrigation.

Furthermore, the urban and industrial water use is representative of the 2013 water requirements and allocations respectively – the MWAAS used the 2003 water requirements, so the two estimates are not directly comparable despite following a similar approach to estimate the yield. For the current estimate, the supply to all irrigation was switched off in order to get an estimate of the firm yield supplied to the urban and industrial users for the 2013 requirements and allocations respectively. The estimate of yield as direct supply from the Mhlathuze Weir is then considered to be representative of the potential volume of water that can be supplied to irrigators in the catchment. The yield estimate assumes a fixed seasonal demand pattern and so could be refined further by applying a varying seasonal demand pattern. Furthermore, it represents the firm yield available at the weir i.e. no failures in supply. If a lower assurance of supply was acceptable, then this estimate could potentially increase. Another important difference is the effect of the Mfolozi River transfer which is temporarily inactive and as such, the supply to RBM will be more dependent on support from Mhlathuze Weir via Lake Nsezi.

Because of the way that the system is operated, with irrigation mostly located in the upper parts of the catchment and schemes being supplied from the Mhlathuze River main stem, and with urban and industrial demands mainly in the lower parts of the catchment, the volume of water available to upstream irrigators is dependent to a certain extent on the volumes supplied to urban and industrial users downstream. In practice, this requires a strict management operating rule. It is also recognised that in reality, the users are located all the way down the system and so they would have access to incremental flows and they would *inter-alia* abstract water from higher up in the catchment.

The results of the yield estimates are shown in Table 1-12.

Table 1-12 | Yield of Mhlathuze system for current study

Scenario	Urban/Industrial water supply (million m3/a)	Irrigation water supply (million m3/a)	Firm yield from Mhlathuze Weir (million m3/a)	Return flows (million m3/a)	Groundwater contribution (million m3/a)	Yield: Combined total water supply (million m3/a)
S1b31: Irrigation = 0 Urban and industrial = 2013 requirements No Mfolozi transfer	95.9 [(a)]	0.0	72.4	10	11	189.3
S1b32: Irrigation = 0 Urban and industrial = allocations No Mfolozi transfer	125.7 [(b)]	0.0	43.2	10	11	189.9
S1b34: Irrigation = 0 Urban and industrial = 2013 requirements Incl. Mfolozi transfer	95.9	0.0	75.4	10	11	192.3
S1b35: Irrigation = 0 Urban and industrial = allocations Incl. Mfolozi transfer	127.8	0.0	55.0	10	11	203.8

Notes:

[(a)] All demands supplied fully, so this supply represents the firm yield

[(b)] All urban demands supplied fully except the supply to RBM Ponds which is supplied at 91% due to infrastructure constraint from Nsezi to RBM. Also, the Mfolozi transfer to RBM is not currently in operation and as such no support from this source has been modelled for either of these scenarios.

Table 1-12 | Yield of Mhlathuze system for current study

Scenario	*Urban/Industrial water supply (million m^3/a)*	*Irrigation water supply (million m^3/a)*	*Firm yield from Mhlathuze Weir (million m^3/a)*	*Return flows (million m^3/a)*	*Groundwater contribution (million m^3/a)*	*Yield: Combined total water supply (million m^3/a)*
S1b31: ***Irrigation = 0*** ***Urban and industrial = 2013 requirements*** ***No Mfolozi transfer***	95.9 [(a)]	0.0	72.4	10	11	189.3
S1b32: ***Irrigation = 0*** ***Urban and industrial = allocations*** ***No Mfolozi transfer***	125.7 [(b)]	0.0	43.2	10	11	189.9
S1b34: ***Irrigation = 0*** ***Urban and industrial = 2013 requirements*** ***Incl. Mfolozi transfer***	95.9	0.0	75.4	10	11	192.3
S1b35: ***Irrigation = 0*** ***Urban and industrial = allocations*** ***Incl. Mfolozi transfer***	127.8	0.0	55.0	10	11	203.8

Notes:

[(a)] All demands supplied fully, so this supply represents the firm yield

[(b)] All urban demands supplied fully except the supply to RBM Ponds which is supplied at 91% due to infrastructure constraint from Nsezi to RBM. Also, the Mfolozi transfer to RBM is not currently in operation and as such no support from this source has been modelled for either of these scenarios.

1.5 Water Balance

The water balance assessment for Richards Bay is summarised in Table 1-13 below for both the allocated water requirements and for the 2013 water use. The estimated water availability under the current configuration is presented, compared to the modelled volumes of water supplied to the users for the allocated / required demand as indicated. No adjustments were made to the individual water users' requirements to obtain a balance at this point in the analysis. Note that the irrigation is modelled as a time-varying demand based on crop area which means that a portion of the crop requirement is satisfied by rainfall. The remaining requirement is abstracted from the river or from storage up to the maximum allocated volume.

Table 1-13 | Richard Bay WSS Water Balance

Water component	Allocated requirement *(million m^3/a)*	Current (2013) modelled supply *(million m^3/a)*
Available water	**195.1**	**195.1**
Total water requirement:	**252.8**	**183.9**
Irrigation	125.0	88.5
Urban	36.9	40.0
Industrial	91.0	55.4
Balance	**-57.7**	**11.2**

2 Conclusions

The Richards Bay/ uMhlathuze Local Municipality area is a centre for industrial and urban development. The water requirements of users in the area are expanding, and this expansion is expected to continue. Various future water requirements scenarios have been developed based on differing assumptions of growth rates for water use sectors and specific water users. These scenarios will be explored and presented in the Scenarios Evaluation Report which is a separate deliverable in this study. The focus of the water balance evaluation has been based on industrial and, to a certain extent, urban requirement. Other uses such as forestry and irrigation have been dealt with in a previous study, but are not likely to expand significantly in the strategy area and have been given less detailed consideration in the current study.

The delimitation of the study area will continue to be refined as the understanding of the system is developed and the relevant water sources are identified.

Further insight into the area's future will be obtained in the succeeding phases of the project, and conclusions will be reached for the best estimate of growth rates and hence the best scenario for future water requirements.

Strategy water balances have been developed using the WRYM to determine firm system yield compared to allocated water requirements and current water use. It is possible that some of these future water requirements may be refined further in the process as improved information is made available.

The modelling findings indicate a reduction in the yield of the WSS, from 214.3 million m^3/a obtained in the MWAAS with irrigation modelled as a time varying demand to 183.9 million m^3/a for the current water use configuration. The same set-up of the WRYM was used as for previous estimations, with some updates to the water requirements.

An important aspect relating to the estimation of yield in the current configuration of the yield model, is the use of irrigation blocks to model time-varying demands as opposed to fixed seasonal demands. This affects the volume of water that needs to be supplied from the source during dry periods, thereby affecting the critical period of the resource and consequently the firm yield that can be obtained during the system yield analysis. Also, by using the volume of water supplied to users as a component of the yield calculation means that this figure needs to be optimised in an iterative approach, as the urban and industrial demands are supplied mainly from the natural lakes with support from Goedertrouw Dam via the Mhlathuze Weir. It is possible that this supplied volume could be higher, thereby changing the yield. It is clear that this is a complex system with many interdependent factors affecting the calculation of yield. Based on the information currently available, the current estimate of yield is considered to be representative of the system at present.

Considering the best estimates of water requirements, indications are that there may still be some small spare capacity in the WSS. In addition, indications are that the irrigation section has further spare capacity because new farmers in especially the land reform areas are not yet farming efficiently or have stopped farming. As other irrigators are entering the sector and replacing existing inefficient irrigators, the irrigation sector is positive that this spare capacity will decrease over time.

3 References

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