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Department of Water Affairs and Forestry

Directorate: National Water Resource Planning

The Assessment of Water Availability in the Berg Catchment (WMA 19) by means of Water Resource Related Models

Report No. 4 : Land Use and Water Requirements Volume 3 : Water Use and Water Requirements



FINAL

May 2009

Submitted by:
Ninham Shand (Pty) Ltd
in Association with
Umvoto Africa (Pty) Ltd

NINHAM  SHAND
CONSULTING SERVICES

UMVOTO



DEPARTMENT OF
WATER AFFAIRS AND FORESTRY

**THE ASSESSMENT OF WATER AVAILABILITY IN THE BERG
CATCHMENT (WMA 19) BY MEANS OF WATER RESOURCE
RELATED MODELS**

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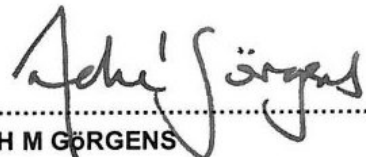
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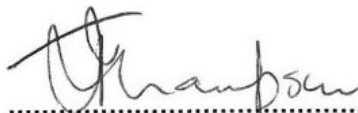


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REPORT No	REPORT TITLE	VOLUME No.	VOLUME TITLE
1	Final Summary Report		
2	Rainfall Data Preparation and MAP Surface		
3	The Assessment of Flow Gauging Stations		
4	Land Use and Water Requirements	Vol 1	Data in Support of Catchment Modelling
		Vol 2	Invasive Alien Plant Mapping
		Vol 3	Water Use and Water Requirements
5	Update of Catchment Hydrology	Vol 1	Berg River
		Vol 2	Upper Breede River
		Vol 3	Peripheral Rivers
6	Water Quality	Vol 1	A Literature Review of Water Quality Related Studies in the Berg WMA, 1994 - 2006
		Vol 2	Updating of the ACRU Salinity Model for the Berg River
		Vol 3	Update Monthly FLOSAL Model to WQT
7	(Report No Not Used)		
8	System Analysis Status Report		
9	Groundwater Model	Vol 1	Overview of Methodology and Results
		Vol 2	Data Availability and Evaluation
		Vol 3	Regional Conceptual Model
		Vol 4	Regional Water Balance Model
		Vol 5	Cape Flats Aquifer Model
		Vol 6	Langebaan Road and Elandsfontein Aquifer System Model
		Vol 7	TMG Aquifer, Piketberg Model
		Vol 8	TMG Aquifer, Witzenberg – Nuy Model
		Vol 9	Breede River Alluvium Aquifer Model
10	Berg and Mhlathuze Assessment Studies (Refer to Report No.1)		
11	Applicability of the Sami Groundwater Model to the Berg WAAS Area		

THE ASSESSMENT OF WATER AVAILABILITY IN THE BERG CATCHMENT (WMA 19) BY MEANS OF WATER RESOURCE RELATED MODELS

LAND USE AND WATER REQUIREMENTS

WATER USE AND WATER REQUIREMENTS

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COMPACT DISC

Input files for WRYM system analysis

ABBREVIATIONS

BRBS	Breede River Basin Study
DWAF	Department of Water Affairs and Forestry
GIS	Geographical Information System
GRA II	Groundwater Resource Assessment Phase II
IAP	Invasive Alien Plant
NGDB	National Groundwater Database
NLCD	National Land Cover Database
SDFS	Skuifraam Dam Feasibility Study
VAFS	Voëlvelei Augmentation Scheme Feasibility Study
WAAS	Water Availability Assessment Study
WARMS	Water Use Authorisation and Registration Management System
WCSA	Western Cape System Analysis
WCWSS	Western Cape Water Supply System
WfW	Working for Water
WMA	Water Management Area
WRSM2000	Water Resources Simulation Model (2000)
WRYM	Water Resources Yield Model
WUA	Water User Association
WWTW	Wastewater Treatment Works

THE ASSESSMENT OF WATER AVAILABILITY IN THE BERG CATCHMENT (WMA 19) BY MEANS OF WATER RESOURCE RELATED MODELS

LAND USE AND WATER REQUIREMENTS

WATER USE AND WATER REQUIREMENTS

EXECUTIVE SUMMARY

The key objectives of the water use and water requirements task aimed at preparing present-day flow sequences for the Water Resources Yield Model (WRYM) is presented. The calibrated hydrological WRSM2000 model was used to generate present-day flow sequences representing existing water use in the study catchments, which will be used in conjunction with the naturalised flow sequences during the system modelling task of the Berg WAAS.

This report presents the present-day flow sequences to be used as input towards updating the WRYM for the Berg, Breede and Peripheral River systems in the system modelling phase of this project. Information on the present-day land and water use is summarised per catchment, while the monthly flow sequence files are provided on CD in a format which is compatible with the WRYM.

1. INTRODUCTION

1.1 BACKGROUND

A key task of the Berg Water Availability Assessment Study (WAAS) relates to the hydrological modelling of the study catchments involved. This task is informed by historical and current land and water use within the study area, which facilitate the calibration of the hydrological models and the subsequent naturalisation of flow sequences. The naturalised flow sequences, in conjunction with estimates of present-day water use and requirements, are then used during the system modelling phase of the Berg WAAS.

The study area for the Berg WAAS includes the Berg Water Management Area (WMA 19) as well as the Palmiet, upper Breede and upper Riviersonderend catchments, which form part of the Breede WMA (WMA 18). In order to assess the availability of water and the use thereof in the study area, which is characterised by extensive areas of irrigation, forestry and invasive alien plants (IAPs), accurate information on land use is a prerequisite. Land use and some water use information is presented in *Report No. 4, Volume 1: Land Use and Water Requirements: Data in Support of Catchment Modelling* (DWAF, 2008) and the final hydrology for all the catchments in the study area, including naturalised flow sequences, is presented in *Report No. 5: Update of Catchment Hydrology* (Volumes 1, 2 and 3) (DWAF, 2009).

1.2 OBJECTIVES

This report provides the present-day water use information in support of updating the existing system model. This includes actual irrigation and streamflow reduction demand sequences, as simulated by the catchment models, information on urban abstractions from reservoirs and the water requirements of the Ecological Reserve.

1.3 APPROACH

Data collection for the purpose of calibrating the hydrological models necessitated the identification and assessment of all water use activities in the study area. This included land use mapping (from 1:10 000 aerial photos in 2004), as well as the collection of data and information that were readily available from regulatory bodies and industries including: the Department of Water Affairs and Forestry (DWAF), irrigation boards, Water User Associations (WUAs) and municipalities for 2006/2007. Registered water use information were also acquired and processed from the Water Use Authorisation and Registration Management System (WARMS) database.

Once the hydrological models were calibrated, naturalised flows for each subcatchment were generated and present-day flow sequences were prepared for the period 1927 to 2004.

This report presents the present-day water use and water requirements for the Berg WAAS surface water study area. Total water demands for each subcatchment are presented in tabular format, while monthly flow sequences for each calibration subcatchment are included electronically on the attached compact disc in the format required as input to the Water Resources Yield Model (WRYM).

2. EXISTING WATER USE AND REQUIREMENTS

This chapter presents the existing water use and requirements for each subcatchment in the study area, which will be used as input to the WRYM system analysis, in tabular format.

2.1 OVERVIEW

Land use in the study catchment is described in detail in *Report No. 4 Volume 1: Data in support of catchment modelling* (DWAF, 2008). The task of updating the catchment hydrology was undertaken and the results are reported in *Report no. 5: Update of Catchment Hydrology, Volumes 1, 2 and 3* (DWAF, 2008). For the purposes of the system analysis, it was necessary to generate present-day flow sequences from the updated hydrology which represent the current level of development in the study catchment. These flow sequences are used as input to the WRYM and are presented in the following sections of this report.

2.1.1 Berg River Catchment

Water use in the Berg River catchment is primarily for irrigation of vineyards and orchards. There are also demands for afforestation in the higher-lying areas as well as riparian and upland alien vegetation infestations. There are some municipal abstractions to Paarl and Wellington, Tulbagh and Saron. There are also major water transfers from the Riviersonderend and from the Upper Breede catchments. For the purposes of this report, the Berg catchment was split into the Upper (up to flow gauge G1H020 at Paarl), Middle (up to flow gauge G1H013) and Lower catchments (downstream of G1H013 to the estuary).

2.1.2 Eerste and Lourens River Catchments

Water use in the Eerste River catchment is primarily for irrigation of vineyards. There is also some afforestation in the upper parts of the catchment, which is concentrated in the Jonkershoek Valley. Similarly in the Lourens River catchment, orchards and vineyards are the main water users with concentrations of afforested areas in the upper catchment areas. The municipal demand from Stellenbosch is supplied via an abstraction from the Jonkershoek River just upstream of Kleinplaas Dam.

2.1.3 Palmiet and Steenbras River Catchments

There is a significant quantity of agricultural water use (predominantly fruit farming and some small areas of vineyards) in the upper Palmiet catchment. Crops are irrigated with water from various dams. There are extensive areas of afforestation in the upper catchment of the Steenbras River, as well as parts of the upper Palmiet. The lower part of the Palmiet catchment forms part of the Kogelberg Nature Reserve and is dominated by mountainous landscape and natural fynbos vegetation. There is very little invasive alien plants in the Palmiet and Steenbras catchments. There is a municipal demand for Grabouw in this catchment.

2.1.4 Diep River Catchment

Most of the agricultural water use in the Diep River catchment is for vineyards, which are mainly found in the upper catchment areas. Fruit and vegetables comprise the rest of the irrigation demand and are found in the middle and lower catchment areas where dryland wheat is also grown. There is no afforestation in the catchment area and the natural vegetation is fynbos.

Alien vegetation, including Black Wattle, Pines, Eucalyptus and Port Jackson, are scattered throughout the catchment in both upland and riparian zones. There are no municipal demands in the Diep River catchment.

2.1.5 Upper Breede River Catchment

The Upper Breede River catchment (tertiary catchment H10), which forms part of the Berg WAAS area, has a relatively small proportion of irrigation compared to the Breede River basin as a whole. Similar to the rest of the basin though, the main irrigated demand is for vineyards and orchards, while pasture makes up most of the remaining demand. There is relatively little afforestation, but widespread, scattered to dense areas of alien vegetation. There is a municipal demand to Ceres which is supplied from the Ceres Dam and to Worcester from the Stettynskloof Dam.

2.1.6 Upper Riviersonderend Catchment

Most of the upper parts of the Riviersonderend Basin have retained their natural vegetation with little agricultural water use. However, lower down where the slopes are flatter, the main agricultural water use is for fruit farming, with smaller areas under vineyard and afforestation. Numerous farm dams in the area supply most of the irrigation, while a small portion of the irrigation water comes directly from rivers. A formal irrigation scheme exists in the vicinity of Villiersdorp where farmers' irrigation requirements are almost exclusively met by abstractions from Elandskloof Dam. The Upper Riviersonderend catchment exhibits extensive areas of invasive alien plants (IAPs), mainly Pines, which occur mostly in the upland areas. Theewaterskloof Dam is situated in the Riviersonderend catchment.

2.2 IRRIGATION WATER REQUIREMENTS

Water requirements for diffuse irrigation in the WAAS area are summarised for each catchment in Table 2.1. In addition, defined irrigation abstractions by various irrigation schemes and water user associations are summarised in Table 2.2. (Monthly irrigation demand sequences per calibration subcatchment are included electronically on the attached CD).

Table 2.1: Diffuse irrigation water demands in the WAAS area (2004)

SUBCATCHMENT	IRRIGATION AREA (km ²)	SOURCE: FARM DAMS (Mm ³ /a)	SOURCE: RIVER (Mm ³ /a)	TOTAL (Mm ³ /a)
<i>Upper Berg</i>	104.4	32.1	34.0	66.1
<i>Middle Berg</i>	216.3	81.8	70.7	152.5
<i>Lower Berg</i>	7.3	3.5	2.0	5.5
Berg Total	328.0	117.4	106.7	224.0
Diep	109.2	42.4	24.9	67.3
Eerste and Lourens	119.7	57.2	9.6	66.8
Palmiet and Steenbras	96.2	38.1	11.9	50.0
Riviersonderend	45.7	42.2	4.6	46.8
Upper Breede	65.4	7.2	6.4	13.6
TOTAL	787.1	304.4	164.1	468.5

Table 2.2: Irrigation Board abstractions in the WAAS area (2007)

SUBCATCHMENT	IRRIGATION BOARD / SCHEME	SOURCE	TOTAL (Mm ³ /a)
BERG	Twenty-Four Rivers Irrigation Board	Twenty-Four Rivers canal	32.95
	De Hoek Estates	Leeu River	4.5*
	Perdeberg Irrigation Board	Berg River	2.1
EERSTE	Eerste River Abstraction	Eerste River	1.5
PALMIET & STEENBRAS	Vyeboom Experimental farm & Nuweberg Dam Syndicate	Nuweberg Dam, Palmiet River	3.7
	Groenland Irrigation Board	Eikenhof Dam: Palmiet River	13.4
	Elgin Orchards	Applethwaite Dam: Palmiet River	1.9
	Elgin Orchards	Grootvlei Dam	1.8
	Arieskraal Dam	Palmiet River	12.6
UPPER BREEDE	Koekedouw Irrigation Board	Ceres Dam	20.8
	Rooikloof Irrigation Board	Rooikloof and Ben Etive Dam	8.7
	Rietvlei Irrigation Board	Titus River	1.0
TOTAL			93.0

* including Saron Municipality

2.3 URBAN DEMANDS

Urban and municipal demands for the major towns in the WAAS area are summarised in Table 2.3. Bulk supply of approximately 300 Mm³/a to the City of Cape Town is supplied directly from Wemmershoek Dam, Steenbras Dam, Voëlvlei Dam and Theewaterskloof Dam, as well as some other localised sources which fall outside the WAAS area. The current volumes for 2007 supplied are summarised in Table 2.4.

Table 2.3: Urban water demands in the WAAS area (2007)

SUBCATCHMENT	TOWN	URBAN DEMAND (Mm ³ /a)
BERG	Tulbagh	1.5
	Paarl	14.2
	Saron*	4.5
EERSTE	Robertsvlei	2.2
	Stellenbosch	4.4
PALMIET	Grabouw	1.1
UPPER BREEDE	Ceres	13.1
	Worcester	12.0
	Prince Alfred Hamlet (DWAF, 2003)	0.4
	Wolesley (DWAF, 2003)	0.9
	Rawsonville (DWAF, 2003)	0.2

* including De Hoek Estates irrigation

Table 2.4: Bulk Water Supply to the City of Cape Town (2007)

SOURCE	TOTAL (Mm ³ /a)
Atlantis (GW)	6.1
Rockview	25.1
Simon's Town	1.0
Steenbras Dam	33.4
Table Mountain dams	3.9
Theewaterskloof Dam	146.4
Voëlvlei Dam	46.0
Wemmershoek Dam	44.8
TOTAL	306.8

2.4 AFFORESTATION WATER DEMANDS

There is approximately 185 km² of commercial forestry in the Berg WAAS area. The calculated demand for the present-day extent of forestry using the streamflow reduction routines in the WRSM2000 model is estimated to be 31.4 Mm³/a. The estimated water demand for the present-day (2004) extent of forestry in each subcatchment is shown in Table 2.5.

Table 2.5: Present-day commercial forestry demands in the Berg WAAS Catchment (2004)

SUBCATCHMENT	AFFORESTATION AREA (km ²)	WATER DEMAND (Mm ³ /a)
<i>Upper Berg</i>	41.8	9.1
<i>Middle Berg</i>	38.3	4.2
<i>Lower Berg</i>	3.3	0.1
Berg Total	83.4	13.4
Diep	1.3	0.0
Eerste and Lourens	31.7	5.5
Palmiet and Steenbras	61.1	10.4
Riviersonderend	6.2	1.8
Upper Breede	1.4	0.1
TOTAL	185.1	31.2

2.5 ALIEN VEGETATION DEMANDS

There is approximately 54 km² of invasive alien plants equivalent to 100% density in the study catchment. The corresponding streamflow reduction calculated by the routines in the WRSM2000 model is estimated to be 11.1 Mm³/a for the present-day extent of alien vegetation. The water demand for invasive alien plants in each subcatchment is shown in Table 2.6.

Table 2.6: Invasive Alien Plants water demands (SFR) in the Berg WAAS Catchment (2004)

SUBCATCHMENT	IAP AREA (km ²)	WATER DEMAND (Mm ³ /a)
<i>Upper Berg</i>	13.4	4.1
<i>Middle Berg</i>	19.6	2.8
<i>Lower Berg</i>	1.8	0.1
Berg Total	34.8	7.0
Diep	2.6	0.1
Eerste and Lourens	11.8	2.7
Palmiet and Steenbras	0.0	0.0
Riviersonderend	1.5	0.7
Upper Breede	3.4	1.3
TOTAL	54.1	11.8

2.6 ECOLOGICAL RESERVE

Provisional estimates of Instream and Estuarine Flow Requirements (IFR and EFR) have been made for the Berg and Breede River catchments. These requirements are currently in use for the continuous water resources planning of the Berg and Breede River catchments and are summarised in Table 2.7.

Estimates of the Reserve for the Breede River catchment were made in the BRBS (DWAF, 2003) for six sites on the Breede River. Two sites fall within the Berg WAAS area, namely Site 1 and 2 which are the Breede River at Mooiplaas, from Witbrug to the confluence with the Wit River, and

the Molenaars River from the confluence with the Elands River to the confluence with the Tierkloof River, respectively.

Estimates of the Reserve for the Berg River were made during the Skuifraam Feasibility Study (DWAF, 1996) for two sites on the Berg River, downstream of the Berg River Dam and upstream of the outlet from Voëlvlei Dam, namely Site 1: downstream of the Berg River Dam and upstream of the Franschhoek River, and Site 2: downstream of Paarl and upstream of the Lorelei diversion Weir.

Table 2.7: Ecological reserve requirements in the Berg WAAS Catchment (Mm³/a)

SUBCATCHMENT	RESERVE CLASSIFICATION	MAINTENANCE LOW FLOWS	MAINTENANCE HIGH FLOWS	RESERVE MAR (Mm ³ /a)
Berg:				
Site 1 (IFR 1/96)	-	31.3	20.1	51.4
Site 2 (IFR 3/96)	-	116.2	62.4	178.6
Upper Breede:				
Site 1	Class D	42.8	41.4	103.0
Site 2	Class B	78.5	45.3	35.4

2.7 GROUNDWATER USE

Information on existing groundwater use in the study area was obtained from the groundwater team (DWAF, 2007) and is summarised for each subcatchment in Table 2.8. Total groundwater use in the Berg WAAS area is estimated to be 93 Mm³/a.

Table 2.8: Existing groundwater use in the Berg WAAS area (WARMS)

SUBCATCHMENT	TOTAL GROUNDWATER USE (Mm ³ /a)
<i>Upper Berg</i>	6.1
<i>Middle Berg</i>	10.0
<i>Lower Berg</i>	2.7
Berg Total	18.8
Diep	13.7
Eerste and Lourens	3.7
Palmiet and Steenbras	1.3
Riviersonderend	1.8
Upper Breede	53.6
TOTAL	92.8

3. PRESENT-DAY FLOW SEQUENCES

The present-day flow sequences representing all water requirements in the study area for the current level of development, i.e. 2004 land use areas and demands, were generated using the calibrated WRSM2000 Pitman model. A summary of the present-day cumulative flows, compared to the simulated naturalised flows, for each of the calibration catchments is shown on Figure 3.1 to Figure 3.6 respectively.

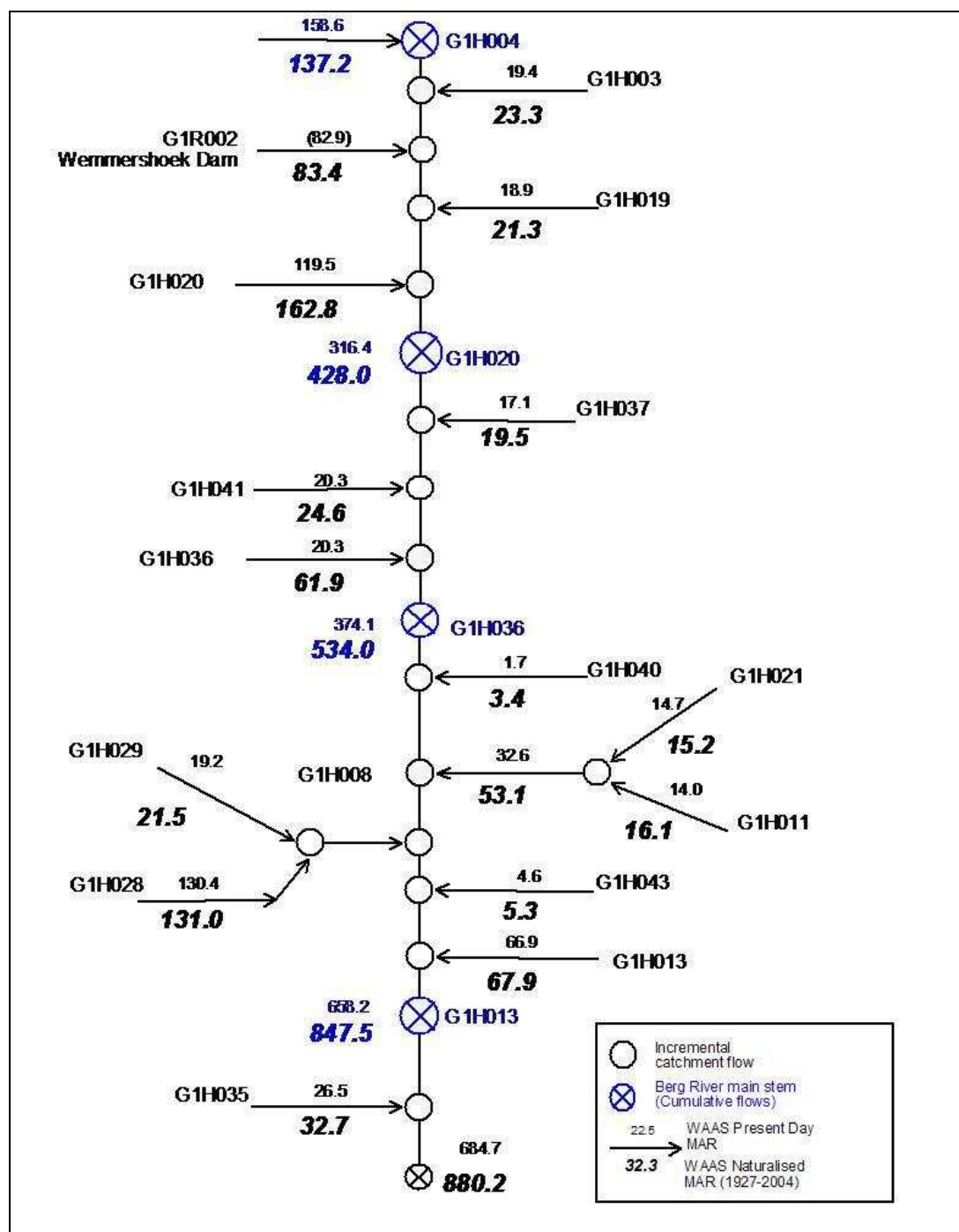


Figure 3.1: Present-day and naturalised flows in the Berg catchment

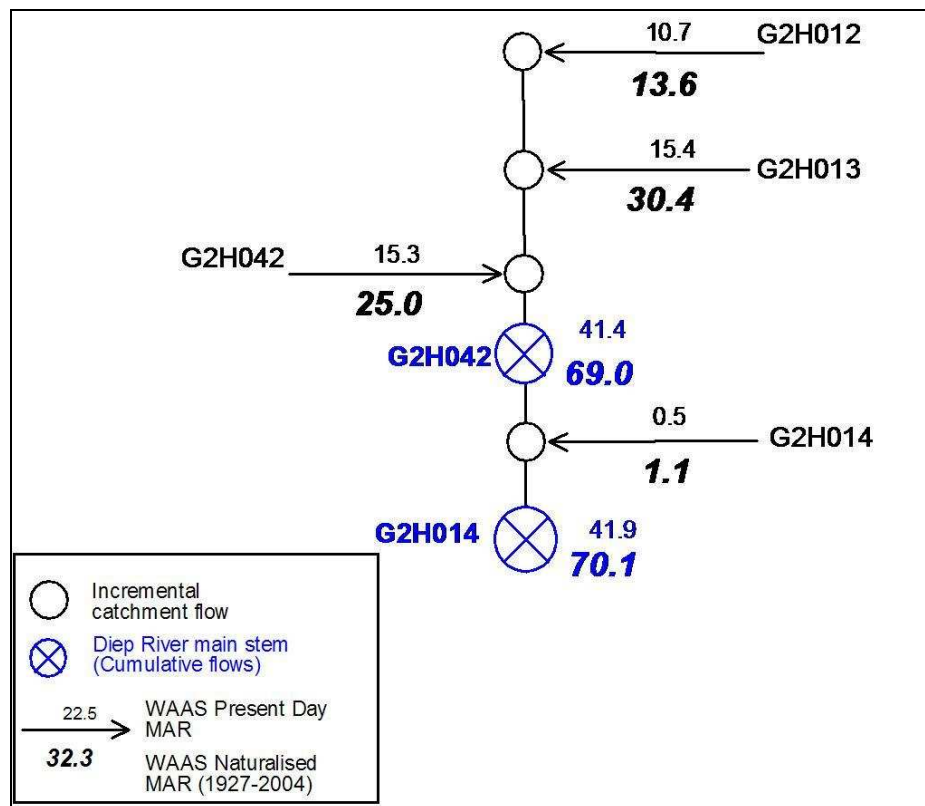


Figure 3.2: Present-day and naturalised flows in the Diep catchment

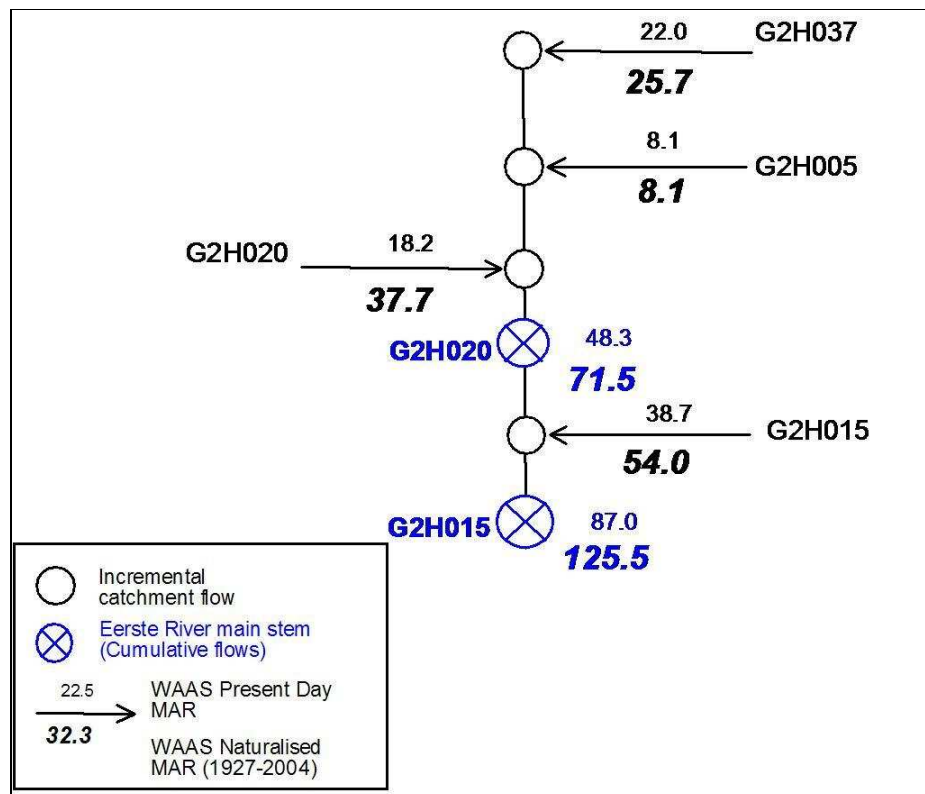


Figure 3.3: Present-day and naturalised flows in the Eerste and Lourens catchment

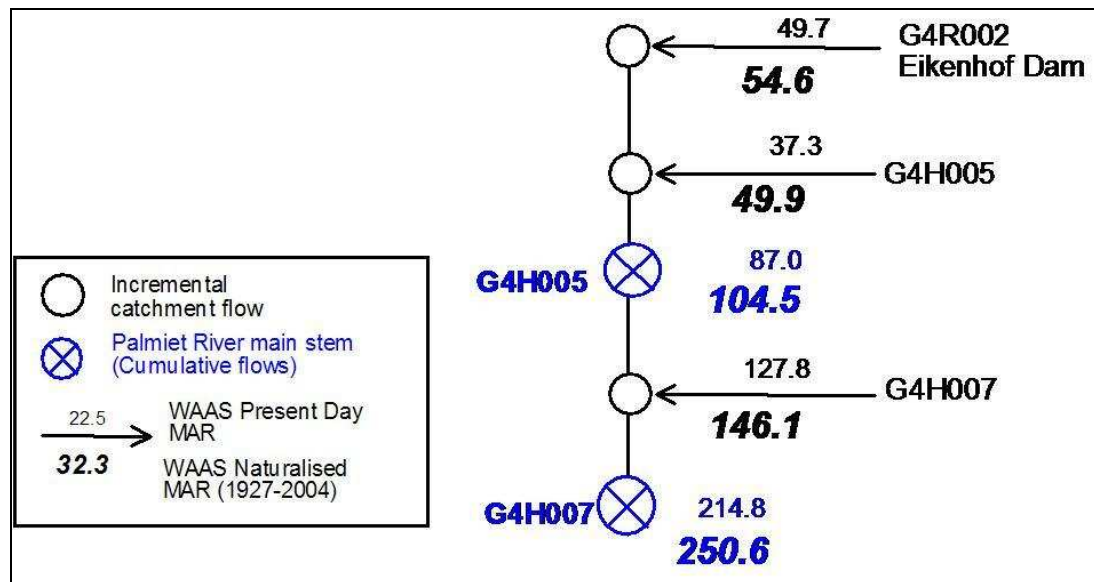


Figure 3.4: Present-day and naturalised flows in the Palmiet and Steenbras catchment

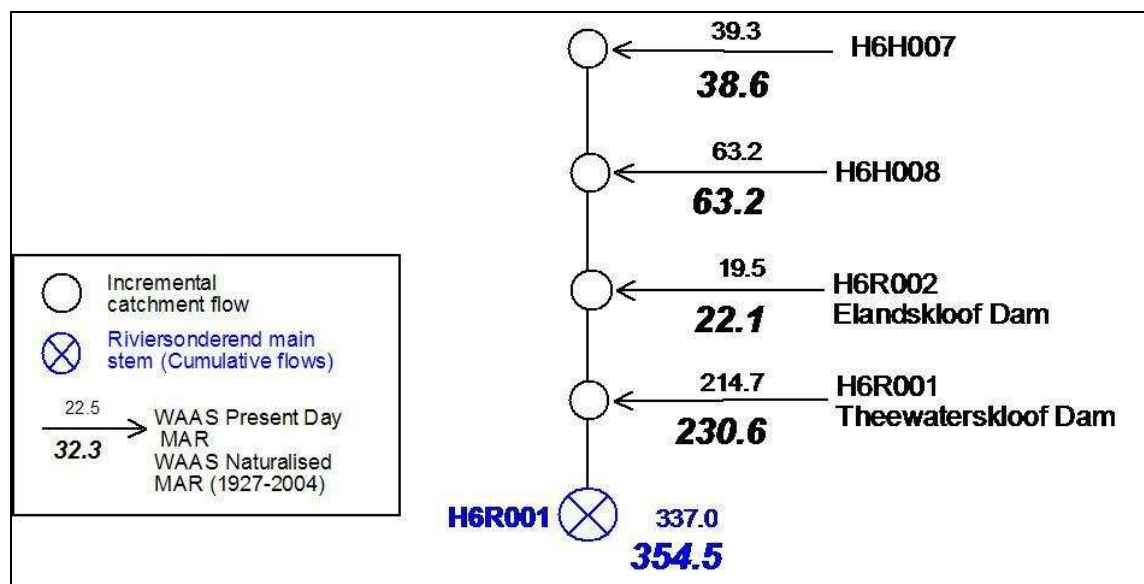


Figure 3.5: Present-day and naturalised flows in the Riviersonderend catchment

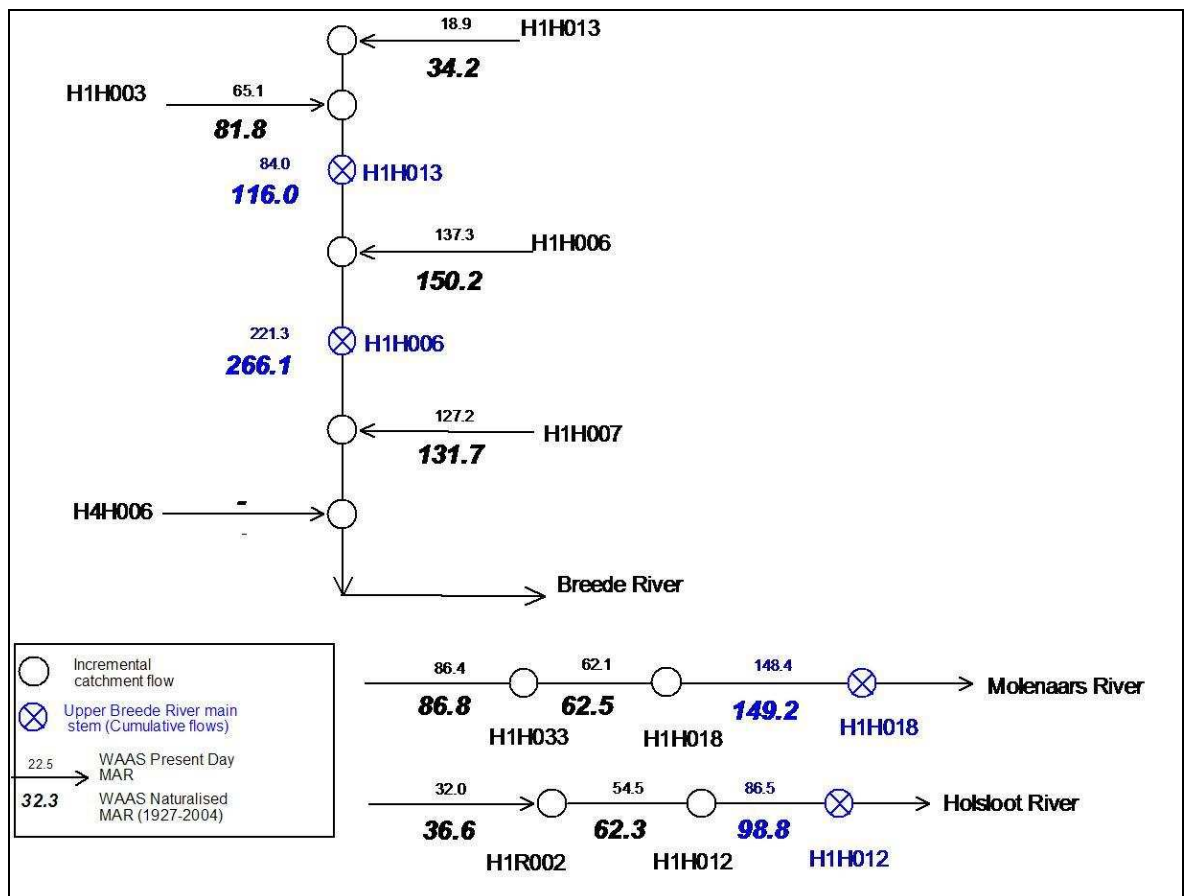


Figure 3.6: Present-day and naturalised flows in the Upper Breede catchment

4. DATA IN SUPPORT OF SYSTEM MODELLING

The data that support the system modelling task for each of the Berg WAAS catchments are included on the CD attached to this report as a series of electronic files to be used directly as input to the WRYM. For each catchment in the Berg WAAS area, these include:

- Naturalised incremental catchment flows,
- Diffuse irrigation demands,
- Afforestation and alien vegetation water demands,
- Urban water demands,
- Inter-basin water transfers.

5. CONCLUSION

The key objectives of the water use and water requirements task aimed at preparing present-day flow sequences for the WRYM were successfully met. The calibrated hydrological model was used to generate present-day flow sequences representing existing water use in the study catchments, which can now be used in conjunction with the naturalised flow sequences during the system modelling task of the Berg WAAS.

This report presents the present-day flow sequences to be used as input towards updating the WRYM for the Berg, Breede and Peripheral River systems in the system modelling phase of this project. Information on the present-day land and water use is summarised per catchment, while the monthly flow sequence files are provided in a format which is compatible with the WRYM.

6. REFERENCES

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