Appendix 4.2: RDM tools and procedures

The various tools, procedures, guidelines, training manuals and other aids that have been developed to support RDM in South Africa are simply too numerous to list here. There are also numerous methods that have been developed for other uses, some of which have been used in RDM studies, but are either not approved by DWA or have proved too difficult to apply in an RDM context, i.e. working fast with a small budget. The methods and tools that are regularly applied to undertake activities required for the Preliminary Reserve Generic Process are listed in Table 4-11 toTable 4-15, as follows:

Support in study initiation and design (Table 4-11)

Models and guidelines for the assessment of ecological condition (Table 4-12)

Reserve assessment methods (Table 4-13)

Models and tools to assist with input to the water quality component of the Ecological Reserve (Table 4-14)

Socio-economic assessment methods (Table 4-15).

Tale 4-11 RDM assessment tools and procedures: Support in study initiation and design

Area addressed	Procedure or tool	Reference	Phase in which development occurred	Description, level of use, status
Assessment level DSS	A DSS designed to assist RDM staff with deciding on the appropriate level of Reserve assessment.	(Louw and Hughes 2002)	Phase 2	Based on criteria such as time and budget constraints, the suitability of existing information and the potential for collecting required information. The level of appropriate assessment is linked to the availability of existing information, and the time allocated to the assessment. If insufficient information is available to relate ecological functioning to the hydrological regime through channel hydraulics and geomorphology, then the confidence in the outcome of a determination will be to low no matter how much effort is put into the study. This potentially valuable DSS is infrequent used by CD:RDM for reasons that are not clear.
(Ecological) Resource Unit delineation	Guidelines for delineating sub-basins, reaches or zones of an ecosystem (e.g. river reaches[1]; hydro-geomorphic wetland types) that are relatively homogenous in terms of morphological, biotic and anthropogenic conditions.	Louw (Kleynhans and Louw 2008; rivers); DWAF (2005 and 2008; wetlands)	Phase 2, although they incorporate information and procedures that were already available in Phase 1, such as ecoregions and site selection.	The approaches used for delineating rivers and wetlands are similar, and usually involve a hierarchical analysis of hydrological, geomorphological and physico-chemical characteristics; biotic communities; and anthropogenic alterations, such as those related to dams or points of significant water quality (e.g. effluent) or quantity (e.g., interbasin transfers) discharges. The aim being to identify a set of representative sites for more detailed study, which will allow the results to be scaled up to represent a larger area. This approach is widely used in Reserve assessments and underpins the delineation tasks in the WRCS.

[1] For the purpose of this document, “reach” is broadly defined as “The reach is a length of channel characterised by a particular channel pattern and channel morphology, resulting from a uniform set of local constraints on channel form (Rountree and Wadeson, 1999). Hundreds of metres to a few kilometres long.”

Table 4-12 RDM assessment tools and procedures: Assessment of importance and ecological condition

Area addressed	Procedure or tool	Reference	Phase in which development occurred	Description
Importance and sensitivity	River	DWAF (1999a)	Phases 1 and 2	EIS and SI assessments are used to guide the setting of a Recommended Ecological Category for EWR assessments. The importance refers to a systems contribution to biological diversity and functioning on local and wider scales. Sensitivity refers to a system's resistance and resilience (Resh *et al*. 1988; Milner 1994) to disturbance. These approaches are widely used in Reserve assessments and underpin the delineation tasks in the WRCS.
	Estuary	Taljaard (2003)		
	Wetlands	None (see Wetlands below)		
	Socio-Cultural Importance (SCI)	Huggins (2000)		
Habitat Integrity	River Index of Habitat Integrity (Wetland IHI)	Kleynhans (1996)	Phase 1, updated in Phase 2 (Kleynhans *et al.* 2009)	Rapid assessments of ecological condition that can be done with minimal training. Habitat Integrity assessments have been replaced to a large extent by the Ecoclassification procedures (see below), but they remain useful for providing quick structured assessments of ecological condition, and as such are still used in desktop and rapid assessments.
	Wetland Index of Habitat Integrity (Wetland IHI)	DWAF (2007b)	Phase 2	
River EcoClassification Index Models	User Manual	Kleynhans and Louw (2007)	Phase 2	The EcoClassification procedures currently in use differ from those in the original concept of Habitat Integrity (Kleynhans 1989) in that they score the physical and biological features of the river relative to natural, whereas the habitat integrity procedures scored the anthropogenic influences based on the assumption that these would result in a deviation from natural. The models have been used in intermediate and comprehensive assessments since *c*. 2004. However, there are some issues with obtaining the latest version of the models, and some are difficult to complete. In instances where there are problems with the models specialists usually revert to their own descriptions and methods for determining ecological condition.
	Hydrological Driver Assessment Index (HAI)	Kleynhans *et al.* (2005)		
	Physico-chemical Driver Assessment Index (PAI)	Kleynhans *et al*. (2005); DWAF (2008f)		
	Geomorphological Driver Assessment Index (GAI)	Rowntree and Du Preez (in prep.)		
	Riparian Vegetation Response Assessment Index (VEGRAI)	Kleynhans *et al.* (2007b)		
	Fish Response Assessment Index (FRAI)	Kleynhans (2007)	Phase 1, updated in Phase 2	
	Macroinvertebrate Response Assessment Index (MIRAI)	Thirion (2007)	Phase 2	
	Fish Frequency of Occurrence database (FROC)	Kleynhans *et al*. (2007a)	Phase 2	Used in conjunction with FRAI. A similar database is under construction for MRAI, and is being considered for IHI and VEGRAI. Extremely useful.

Area addressed	Procedure or tool	Reference	Phase in which development occurred	Description
Estuary	Estuarine Health Index	Adams *et al*. (2002)		The specialists assess the extent to which changes in the flow regime have affected the frequency and duration of mouth closures, which is then used to assess the biological response. The approach is used in all estuarine Reserve assessments.
Wetlands	PES and EIS assessment for wetlands	None.	Phase 3	Modification of the Habitat Integrity assessment, which is applied at a quaternary catchment scale. Has been recently applied in for wetlands in the Outeniqua, Mkomati, Mokolo and Upper Vaal basins. Awaiting DWA approval.

Table 4-13 Environmental Water Requirement assessment methods

Name	Description	Reference	Manual available?	RDM level(s) used at.	Comment
Rivers					
BBM	JMK	King *et al* (1998). Updated (King *et al.* 2008).	Yes. King *et al*. (2008)	Previously Intermediate; Comprehensive. Desktop and Rapid	The BBM principles form the basis of the Desktop Reserve Model estimates.
Desktop Model	Uses the relationship between the outcome of previous Reserve assessments and hydrology to predict Reserves for new systems. The percentage MAR recommended varies depending on the hydrological nature of the target river. This is captured in the Hydrological Index CVB, where strongly perennial systems have a low index value and ephemeral rivers a high index value. For example, the data set for **Error! Reference source not found.** comprises the results of past comprehensive EF studies and only includes rivers with index values up to 9.0, while most studies were done in rivers with indices in the region of 1.8 to 6.0. Thus the estimates for rivers with higher index values have a low confidence.	Hughes and Hannart (1999). Updated (Hughes and Munster 2003).	No.	Desktop; Rapid I, II and III.	Widely used in desktop and rapid RDM studies. The IFR Edit Module is also used in the WRCS to extrapolated data from detailed study sites to other locations in the basin.
HFSR Method	Evaluates the change in habitat conditions for a range of lowflow conditions and the resulting ecological responses. Uses this stress index either set flows at different assurances and seasons for a range of ecological categories, or to evaluate flow scenarios to assess the resulting ecological categories.	After O'Keeffe *et al.* (2002)	Yes (IWR Source-to-Sea 2004)	Intermediate; comprehensive.	Widely used in RDM studies. The stress indices can also be used in rapid assessments and will form the basis of the revised Desktop. The manual is outdated as many new tools have been developed since it was compiled.
DRIFT Method	Uses response curves between flow indicators and a range of biophysical indicators to describe the implications of flow change relative to present day.	King *et al.* 2003.	Yes. Brown *et al*. (2008)	Intermediate; comprehensive.	Widely used in RDM studies in the Western Cape. However most of its applications have been outside of South Africa.

Name	Description	Reference	Manual available?	RDM level(s) used at.	Comment
Wetlands					
Rapid Reserve Determination methods for Wetlands	Uses a similar approach to BBM to define lowflow and flood requirements for wetlands.	Rountree (2010)	Yes. Rountree (2010).	Rapid	Has been tested across a range of wetlands types but has not yet been widely applied.
Hydrological approach to determine pan inundation	An hydrological approach using rainfall-inundation correlations for determining the patterns of pan inundation.	Fluvius (2007)	No.	Rapid	Very low confidence assessment used to identify the historic patterns of pan inundation to guide management and set RQO's. Basic biotic information was used to guide the EWR requirements.
Estuaries					
RDM method for estuaries	RDM method for estuaries	DWAF (1999b)	Yes. DWAF (1999b).	Rapid, Intermediate and Comprehensive	Used for every estuarine Reserve assessment in the country. Updated and adjusted as required in discussion with estuarine environmental flow specialists.
	Update of RDM method for estuaries based on lessons learnt	DWAF (2004b)			
	Desktop assessment	DWA (2009)	No.	Desktop	Recently developed through application for the Gwaing Estuary. Will require additional applications and revision before being accepted for wider use.
Groundwater					
Herold Method	Use to calculate groundwater contribution of the baseflow and surface runoff. Comprises a model that computes monthly basis diffuse salt loads associated with runoff.	Herold (1980)	Yes (Herold 1980).	Desktop, Rapid	Widely used in RDM studies to determine the groundwater component of the Reserve.

Name	Description	Reference	Manual available?	RDM level(s) used at.	Comment
Sami Model	Use to calculate groundwater contribution of the baseflow and surface runoff.	DWAF (2006)	Yes (DWAF 2006)	Rapid, Intermediate and Comprehensive	Ongoing discussion about which, if any of these, model is most suitable for determining the groundwater contributions to Reserve baseflows.
Groundwater Resource Directed Measures (GRDM) Method	Alternate methods for determination of the Groundwater Reserve, which are currently being compared and evaluated.	IGS (2006)	Yes (IGS 2006).	Rapid, Intermediate and Comprehensive	
Groundwater Yield Model for the Reserve (GRYM) Method		DWA (2010)	No.	Rapid, Intermediate and Comprehensive	

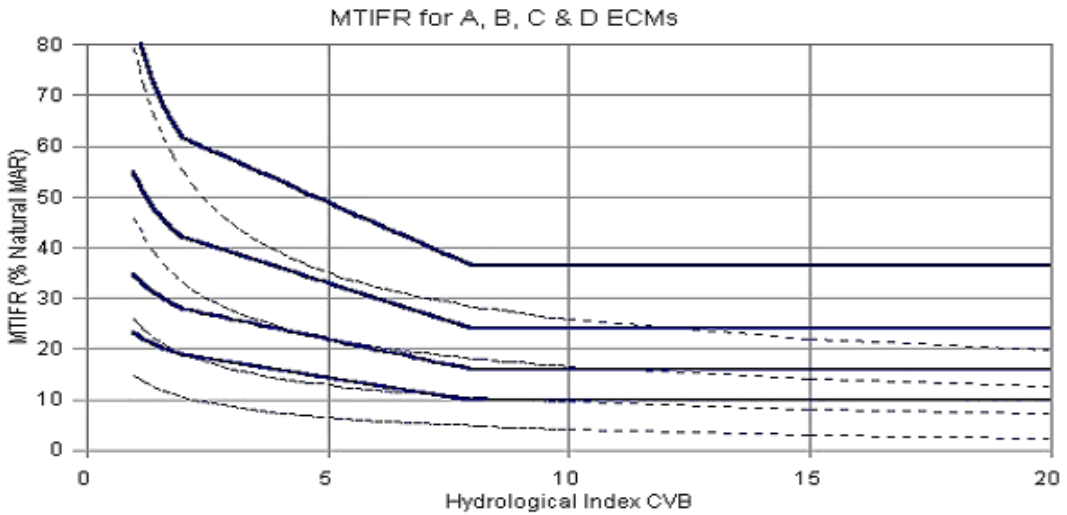

Figure 4-3 Maintenance total IFR requirements for A, B, C and D category rivers. The heavy lines are the total flow requirements, while the broken lines represent the low flow requirements. The high flow requirements are the differences between the two sets of lines.

Table 4-14 Models and tools to assist with input to the water quality component of the Ecological Reserve

Name	Description	Reference	Used for:	Comment
A draft manual for the determination of the water quality component of the Ecological Reserve, which consolidates several different approaches, was produced in Phase 2 (DWAF 2002; DWAF 2008f). However, the paucity of appropriate water quality modeling methods, or a systems model for water quality for RDM requirements, is a critical gap in the current method.				
TEACHA	Analytical tool. This is currently the only tool available for the production of aggregated salts from chemical data.	DWAF (2004c; 2008f) – includes TEACHA notes and model information as prepared by Jooste S, DWAF: RQS.	Physico-chemical data analysis and production of ratings to be used in the PAI model.	Further development is needed as data input problems are regularly experienced. This tool is of particular value in desktop assessments.
PAI model	Model used to generate a PES of the water quality component of the Ecological Reserve.	Kleynhans *et al.* (2005); DWAF (2008c).	Generation of the integrated water quality present state category for the Ecological Reserve.	See **Error! Reference source not found.**.
Resource Water Quality Objectives (RWQO) Model	Model to be used by DWAF RO / practitioners to determine the most sensitive user for which RQO will be prescribed.	-	To determine the most sensitive user according to which RWQOs will be prescribed. Quality Ecospecs from the Reserve process form the ecological input data.	Version 5.0 released in 2009. Some DWAF staff members have been trained in the use of the model but it has not yet been widely used.
Flow-concentration Model	Simple flow-concentration modeling using parameters with strong flow-concentration relationships, e.g. salts.	Malan and Day (2002), Malan *et al.* (2003), Malan (2004).	Integration of quality and quantity and to provide water quality consequences of a range of predicted flow scenarios.	The model is of limited use for non-conservative variables such as nutrients (i.e. those variables that undergo biological and chemical conversion, and their concentration is altered by factors other than water volume e.g. bacterial degradation).
Water Resources Planning Model (WRPM)	The WRPM can be used to simulate water quality scenarios for Total Dissolved Solids (TDS) (i.e. salinity) under different management and flow scenarios.	Trevor Coleman modeled this for the Vaal system (DWAF 2008g).	Simulates TDS concentrations under various management and flow scenarios.	The use of this tool is restricted to TDS – a similar approach is needed for other variables, particularly nutrients.

Table 4-15 Socio-economic RDM tools

Name	Description	Reference	Used for:	Comment
Basic Human Needs Determination Approach	Word document outlining suggested approach to determining quantity of water required for satisfaction of the Basic Human needs component of the reserve	Huggins (2008). Draft submitted to Department of Water Affairs for comment.	Determination of Basic Human Needs	Method proposed in the model is applicable to all catchments in the RSA.
Socio- Cultural Importance	Spreadsheet with model for determining the importance of quaternary catchments with respect to socio-cultural importance	-	Determination of Socio Cultural Importance at level of quaternary catchment.	Spreadsheet needs some expert input as weighting varies with nature of the catchment/resource being studied
Framework and Manual for the evaluation of aquatic ecosystems services for the Resource Directed Measures	A four-part methodology which is consonant with RDM procedures, incorporates the Millennium Ecosystm Assessment framework and makes use of best international standards of resource economics	Ginsberg *et al.* (2009).	Evaluation of aquatic ecosystems services.	The method has been applied to the Crocodile and Marico Basins, and is planned for application in the Mzimkulu Basin.

Appendix 4.3: Reserve template

PRELIMINARY DETERMINATION OF THE RESERVE AND RESOURCE CLASS IN TERMS OF SECTION 14(1)(b) AND 17 (1) OF THE NATIONAL WATER ACT, 1998 (ACT NO. 36 OF 1998)

I, **HARRISON HURSINEY PIENAAR**, in my capacity as Chief Director: Resource Directed Measures and duly authorised in terms of section 63 of the National Water Act, 1998 (Act No. 36 of 1998), do hereby declare the preliminary determination of the Reserve and preliminary resource class as contained below.

_____

CHIEF DIRECTOR: RESOURCE DIRECTED MEASURES

DATE:

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1 Description of the Surface Water Resource.

River : Dwars River
Drainage Region: B41H (at EWR site, S24° 50' 38.1"; E30° 05' 30.8")
Water Management Area: Olifants

2 Preliminary determination of the Reserve for Water QUANTITY for surface and groundwater in terms of section 17(1)(a)

- **Surface water: 27.6%** of the Mean Annual Runoff of **31.4** million cubic metres.
- **Groundwater: 38%** of the mean annual Recharge of **8.62** million cubic metres.

NOTE: In respect to **surface water**, the amount accounts for both the ecological Reserve (25.9%) and the basic human needs Reserve (1.7%).

3 Preliminary determination of the Reserve for Water Quality in terms of section 17(1)

The Reserve (Ecological and Basic Human Needs) for water quality is determined on a preliminary basis and is defined by the minimum water quality specifications provided in Annexure B.

Note: Streamflow at each Ecological Water Requirement (EWR) site must at all times comply in all respects with the water quality specifications set for the particular site.

4 Preliminary determination of the resource class in terms of section 14(1)(b)

Equivalent to the recommended ecological Reserve category of B/C. Category B/C represents a largely natural to moderately modified state.

5 Applicability

5.1 This preliminary determination of the Reserve in terms of section 17(1)(a) is applicable to the following water resource or part of the resource: Dwars River, cumulative at the EWR site (S24° 50' 38.1"; E30° 05' 30.8") in quaternary catchment B41H.

5.2.1 This preliminary determination of the Reserve in terms of section 17(1)(b) is applicable to the authorising of following water uses:

- Section 21(a) – taking water from a water resource.
- Section 21(b) – storing of water.
- Section 21(c) – impeding or diverting the flow of water in a watercourse.
- Section 21(d) – engaging in a streamflow reduction activity.
- Section 21(f) – discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit.
- Section 21(g) – disposing of waste in a manner which may detrimentally impact on a water resource.
- Section 21(i) – altering the bed, banks, course or characteristics of a watercourse.
- Section 21(j) – removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people.
- Section 21(k) – using water for recreational purposes.

6 Additional supporting documentation is provided in the following Annexures

Annexure A: Preliminary Ecological Reserve – Water Quantity	☒
Annexure B: Preliminary Ecological Reserve – Water Quality	☒
Annexure C: Preliminary Groundwater Reserve – Water Quantity	☒
Annexure D: Basic Human Needs Reserve	☒
Annexure E: Resource Quality Objectives	☐
Annexure F: Background and Record of Decision	☒
Annexure G: Methodology	☒
Annexure H: Specialist Reports	☒
Annexure I: Map of Study Area	☒

ANNEXURE A

PRELIMINARY ECOLOGICAL RESERVE:

WATER QUANTITY

RIVER ECOSYSTEMS COMPONENT – WATER QUANTITY

1. Level of confidence of the determination: Medium
2. The determination is applicable to the cumulative flow at the EWR site in quaternary catchment B41H. This means that the Ecological Water Requirements (EWR) are based on the natural flow contribution of the catchments upstream of B41H up to the EWR site at S24° 50' 38.1"; E30° 05' 30.8".
3. Table 1 provides a summary of the flow characteristics and EWR requirements.
4. Table 2 provides a summary of EWR rule curves for the water quantity component of the ecological Reserve.

Table 1 Summary of EWR estimates at the EWR site (S24° 50' 38.1"; E30° 05' 30.8") in Quaternary Catchment: B41H

Desktop Version 2, Printed on 2008/04/21 Summary of EWR estimate for: Dwars_EWR1

Total runoff, cumulative at EWR Site 1 (S24° 50' 38.1"; E30° 05' 30.8") in quaternary catchment B41H

Annual Flows (Mill. cu. m or index values):
MAR = 31.429*
S.Dev. = 22.106
CV = 0.703
Q75 = 0.660 (Q75/MMF = 0.252)
BFI Index = 0.431
CV(JJA+JFM) Index = 1.747

REC = B/C**

Total IFR = 8.142 (25.91 %MAR)
Maint. Lowflow = 6.099 (19.41 %MAR)
Drought Lowflow = 2.289 (7.28 %MAR)
Maint. Highflow = 2.042 (6.50 %MAR)

Monthly Distributions (cu.m./s)
Distribution Type : Olifants

Month	Natural Flows			Modified Flows (IFR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	0.337	0.418	0.463	0.107	0.043	0.060	0.167
Nov	1.149	1.464	0.492	0.160	0.061	0.060	0.220
Dec	1.841	1.754	0.356	0.215	0.080	0.144	0.359
Jan	1.977	2.007	0.379	0.251	0.092	0.141	0.392
Feb	2.230	2.964	0.550	0.310	0.113	0.293	0.603
Mar	1.576	2.140	0.507	0.280	0.102	0.094	0.374
Apr	1.049	0.902	0.332	0.264	0.097	0.000	0.264
May	0.659	0.530	0.300	0.215	0.080	0.000	0.215
Jun	0.420	0.244	0.224	0.173	0.066	0.000	0.173
Jul	0.305	0.137	0.168	0.134	0.052	0.000	0.134
Aug	0.257	0.131	0.190	0.114	0.045	0.000	0.114
Sep	0.242	0.122	0.195	0.107	0.043	0.000	0.107

* Virgin mean annual runoff (VMAR) based on the total flow from quaternary catchment B41G and 18% of B41H. Flow record scaled from the Steelpoort River flow record as determined during the high confidence Reserve determination study for the Olifants River.

** Recommended Ecological category determined during the intermediate Reserve determination study on the Dwars River at EWR site (S24° 50' 38.1"; E30° 05' 30.8") in quaternary catchment B41H.

Table 2 Summary of EWR Rule Curves for the EWR site (S24° 50' 38.1"; E30° 05' 30.8") in Quaternary Catchment: B41H

Desktop Version 2, Printed on 2008/04/21 Summary of EWR rule curves for: Dwars_EWR1

Total runoff, cumulative at EWR site 1 (S24° 50' 38.1"; E30° 05' 30.8") in quaternary catchment B41H
Regional Type : Olifants
REC = B/C**

Data are given in m^3/s mean monthly flow

	% Points									
Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.199	0.198	0.195	0.188	0.175	0.155	0.126	0.092	0.063	0.050
Nov	0.266	0.265	0.262	0.256	0.244	0.224	0.192	0.148	0.099	0.068
Dec	0.429	0.426	0.421	0.411	0.392	0.358	0.305	0.231	0.148	0.096
Jan	0.586	0.548	0.514	0.480	0.443	0.379	0.324	0.248	0.162	0.108
Feb	0.956	0.878	0.809	0.745	0.678	0.565	0.479	0.361	0.229	0.146
Mar	0.531	0.505	0.480	0.455	0.424	0.372	0.319	0.246	0.165	0.113
Apr	0.326	0.324	0.319	0.309	0.289	0.258	0.214	0.162	0.119	0.098
May	0.265	0.264	0.260	0.251	0.236	0.210	0.174	0.133	0.098	0.081
Jun	0.214	0.212	0.209	0.202	0.190	0.170	0.141	0.108	0.080	0.067
Jul	0.165	0.164	0.162	0.157	0.147	0.132	0.110	0.084	0.063	0.053
Aug	0.141	0.140	0.138	0.133	0.125	0.112	0.094	0.072	0.054	0.046
Sep	0.132	0.131	0.129	0.125	0.118	0.106	0.088	0.068	0.051	0.044
Reserve flows without High Flows										
Oct	0.132	0.131	0.129	0.125	0.118	0.106	0.088	0.068	0.051	0.044
Nov	0.199	0.198	0.196	0.192	0.184	0.170	0.148	0.117	0.083	0.062
Dec	0.268	0.266	0.263	0.258	0.247	0.228	0.198	0.157	0.110	0.081
Jan	0.312	0.311	0.307	0.301	0.288	0.266	0.231	0.182	0.128	0.093
Feb	0.386	0.384	0.380	0.371	0.356	0.328	0.285	0.224	0.157	0.115
Mar	0.348	0.347	0.343	0.335	0.321	0.296	0.257	0.203	0.142	0.104
Apr	0.326	0.324	0.319	0.309	0.289	0.258	0.214	0.162	0.119	0.098
May	0.265	0.264	0.260	0.251	0.236	0.210	0.174	0.133	0.098	0.081
Jun	0.214	0.212	0.209	0.202	0.190	0.170	0.141	0.108	0.080	0.067
Jul	0.165	0.164	0.162	0.157	0.147	0.132	0.110	0.084	0.063	0.053
Aug	0.141	0.140	0.138	0.133	0.125	0.112	0.094	0.072	0.054	0.046
Sep	0.132	0.131	0.129	0.125	0.118	0.106	0.088	0.068	0.051	0.044
Natural Duration curves*										
Oct	0.534	0.452	0.317	0.261	0.246	0.190	0.179	0.164	0.149	0.108
Nov	3.981	1.586	0.965	0.764	0.610	0.455	0.382	0.313	0.212	0.127
Dec	4.962	3.524	2.139	1.837	0.960	0.780	0.605	0.508	0.399	0.179
Jan	4.716	2.991	2.113	1.714	1.262	1.068	0.862	0.728	0.411	0.317
Feb	6.510	2.670	1.732	1.368	1.108	0.897	0.728	0.637	0.500	0.335
Mar	3.483	1.714	1.329	1.068	0.877	0.769	0.646	0.508	0.411	0.220
Apr	2.211	1.447	1.246	1.007	0.795	0.652	0.567	0.413	0.297	0.185
May	1.385	1.027	0.687	0.564	0.523	0.452	0.329	0.302	0.261	0.164
Jun	0.764	0.567	0.440	0.382	0.340	0.297	0.282	0.255	0.228	0.154
Jul	0.523	0.399	0.317	0.287	0.273	0.261	0.220	0.205	0.190	0.123
Aug	0.370	0.329	0.261	0.246	0.220	0.205	0.205	0.179	0.164	0.108
Sep	0.440	0.282	0.239	0.212	0.197	0.197	0.185	0.170	0.154	0.100

* Virgin mean annual runoff (VMAR) based on the total flow from quaternary catchment B41G and 18% of B41H. Flow record scaled from the Steelpoort River flow record as determined during the high confidence Reserve determination study for the Olifants River.

** Recommended Ecological Reserve category determined during the intermediate Reserve determination study on the Dwars River at EWR site (S24° 50' 38.1"; E30° 05' 30.8") in quaternary catchment B41H.

ANNEXURE B

PRELIMINARY ECOLOGICAL RESERVE:

WATER QUALITY

RIVER ECOSYSTEMS COMPONENT – WATER QUALITY

Table 1 Site information summary for the water quality component of intermediate Dwars River Reserve

	Reference State	Present state	Comments
Station name	B4H009Q01	B4H009Q01	To continue or institute bi-monthly monitoring at DWAF's gauging weir, B4H009Q01
Full data period	1977–2007: 1058 samples		
Total number of records used	1977-1981: n=95 (but 207 for EC)	2005-2007: n=62 (but 66 for TIN)	
Trend significance		Stable	Causes for concern would be spillage from slimes dams during "upset" conditions
Known point sources of pollution upstream		Irrigation runoff and mining activities	Elevated nutrient status and toxics
Other land-uses		None	
EISC (Ecological Importance and Sensitivity Category)		High	
PESC (Present Ecological State Category) or EcoStatus		B/C	
Recommended water quality category of the overall REC		B/C	
Software or method used			Data analysis using Excel and PAI model
Confidence	Confidence in the assessment is **moderate** due to the small database of information available for temperature, oxygen, turbidity and toxics.		

NOTE:
This Reserve is recommended under the following constraints:-

- Use of the best available scientific knowledge and method (software)
- Based on available data

Table 2 Water quality specifications (Quality Ecospecs) for the intermediate Reserve of the Dwars River

Quality Constituent	Parameter	Ecological Reserve Requirements	Basic Human Needs Requirement[5]	Reserve Requirement: water quality
General chemistry – major inorganic salts	$MgSO_4$ (mg/l) [1]	< 16	N/A	< 16
	Na_2SO_4 (mg/)l [1]	< 20	N/A	< 20
	$MgCl_2$ (mg/l) [1]	< 15	N/A	< 15
	$CaCl_2$ (mg/l) [1]	< 21	N/A	< 21
	NaCl (mg/l) [1]	< 45	N/A	< 45
	$CaSO_4$ (mg/l) [1]	< 351	N/A	< 351
General chemistry – Major Ions	Sodium (mg/l)	N/A	<200	<200
	Magnesium (mg/l)	N/A	<100	<100
	Chloride (mg/l)	N/A	<200	<200
	Calcium (mg/l)	N/A	<80	<80
	Sulphate (mg/l)	N/A	<400	<400
Nutrients	Phosphate (PO_4) (mg/l) [2]	<0.021mg/L	N/A	<0.021mg/L
	Total Inorganic Nitrogen (mgN/l)[2]	<4.0mg/L	N/A	<4.0mg/L
Physical water quality	pH (range) 5th percentile 95th percentile	6.5 8.8	5 9.5	6.5 8.8
	Dissolved Oxygen (mg/l)[1]	>7 mg/L	N/A	>7 mg/L
	Temperature[1]	Vary by no more than 2°C from the natural range (samples to be taken at approximately the same time every day)		Vary by no more than 2°C from the natural range
	Electrical conductivity (mS/m) – USE ONLY IF AGGREGATED SALTS NOT AVAILABLE	≤55mS/m	0-70	≤55mS/m
Biological water quality	Chl-a: periphyton[3]	<63 mg/m^2	N/A	
	Chl-a: phytoplankton[3]	< 10 µg/L (A category)	N/A	
	Biotic community composition - macroinveterbrates	ASPT: 6 (B/C category)		
	In-stream toxicity	In-stream toxicity should not occur		
Toxics and complex mixtures	Toxics (as listed in DWAF, 1996 [6])	≤ TWQR	≤ TWQR	≤ TWQR

NOTES:

[1] : 95th percentile compliance.
[2]: 50th percentile compliance
[3] Chl-a is not applicable to Desktop Reserve studies
[4] 90th percentile compliance
[5] ref: *South African Water Quality Guidelines, Volume 1: Domestic Water Use*, *2nd Ed.* 1996. Department of Water Affairs and Forestry. Pretoria, South Africa.
[6] ref: *South African Water Quality Guidelines, Volume 7: Aquatic Ecosystems*, *2nd Ed.* 1996. Department of Water Affairs and Forestry. Pretoria, South Africa.

Where a difference in the water quality values for the Ecological Reserve and Basic Human Needs Reserve was found, the stricter or more protective value was selected for the water quality component of the Reserve.

ANNEXURE C

PRELIMINARY GROUNDWATER RESERVE:

WATER QUANTITY

GROUNDWATER RESERVE DETERMINATION — QUANTITY

Quaternaries	Area (km^2)	Recharge[1] (Mm^3/a)	Groundwater component of baseflow[2] (Mm^3/a)	Baseflow for EWR (Mm^3/a)	Reserve as % of Recharge
B41G & B41H	442	8.62	4.67	3.29	38

Notes

- Recharge calculated as 3% of MAP of 650mm.
- The baseflow for EWR is based on a Maintenance Low Flow (MLF) of 0.122 m^3/s for a category B/C.

Definitions

- **Recharge**: Water reaching the aquifer directly from precipitation and the infiltration of surface water. [1]
- **Baseflow:**[2] Baseflow is that part of stream flow that derives from groundwater and shallow subsurface storage. During the dry season, the stream flow is typically composed entirely of baseflow. [2]
- **Groundwater component of baseflow:** This is the component of Baseflow that derives from the aquifer adjacent to a surface water body, and excludes interflow in the vadose zone or short–term storm events which saturate the subsurface soil and discharge to a surface water body before reaching the aquifer. The Herold Baseflow Separation Model is used. [2]
- **Baseflow required by EWR:** The volume of baseflow required by the instream flow requirements set for the surface water component of the Reserve.
- **The Reserve** constitutes the sum of the baseflow required by IFR plus the BHN reserve expressed as a percentage of the Recharge.

1) Bredenkamp, D.B., Botha L.J., van Tonder, G.J. and Van Rensburg, H.J. (1995). Manual on quantitive estimation of groundwater recharge and aquifer storativity. WRC Report TT 73/95

2) Herold, C.E. (1980). A model to compute on a monthly basis diffuse salts associated with runoff. HRU report no 1/80.

[2] This is the definition as provided in the official templates. The definition included in the Groundwater Dictionary is as follows: "Sustained low flow in a river during dry or fair weather conditions, but not necessarily all contributed by groundwater; includes contributions from interflow and groundwater discharge."

ANNEXURE D

BASIC HUMAN NEEDS

BASIC HUMAN NEEDS RESERVE

The basic human needs reserve provides for the essential needs of individuals served by the water resource in question and includes water for drinking, food preparation and for personal hygiene. A lifeline amount of 25 litres per person per day was used.

Quaternary	Population (Current requirement)	Per capita need (Litres / day)	BHN Reserve required	
			MCM / annum	% VMAR
B41H	58 478*	25	0.5336	1.7

* This figure includes the total population of quaternary catchment B41H

MCM: million cubic metres
VMAR: virgin mean annual runoff

The cumulative VMAR at the EWR site (S24° 50' 38.1"; E30° 05' 30.8") in quaternary drainage region B41H is 31.4 million cubic metres.

ANNEXURE F

BACKGROUND AND RECORD OF DECISION

BACKGROUND AND RECORD OF DECISION

Study Team

Project management:	
DWAF: RDM	B Weston
Consultants	R Stassen
	E van Niekerk
	P Scherman
	M Rountree
	M Graham
	B Niehaus
	P Kotze
	J Crafford
	A Jordonova

Compilation of Reserve determination report:

JMM Stassen:	R Stassen

Motivation for Reserve Determination

This preliminary determination of the Reserve was undertaken for quaternary catchments B41G and B41H in response to the construction of the proposed Richmond Dam and the associated license applications in the Dwars River catchment related to mining activities.

Scope of Study

A preliminary determination for both the surface (quantity and quality) and groundwater (quantity) component of the ecological Reserve as well as the basic human needs Reserve for the Dwars River in quaternary catchment B41H, using a medium confidence procedure, was undertaken. The Reserve determination study was undertaken at the EWR site (S24° 50’ 38.1”; E30° 05’ 30.8”) in quaternary catchment B41H.

ANNEXURE G

METHODOLOGY

METHODOLOGY USED

Ecological Reserve

The methodology used for the determination of the ecological Reserve (**surface water**) is that set out in *DWAF (1999): Resource Directed Measures for Protection of Water Resources; Volume 3: River Ecosystems Version 1.0*

The methodology used for the determination of the water quality component of the ecological Reserve is that set out in:

DWAF (2002): Hazard-based water quality ecological specifications for the Ecological Reserve in fresh water Resources. Report No. N/0000/REQ0000. Institute for Water Quality Studies, Department of Water Affairs and Forestry. Author: Jooste S.

DWAF (2008): Methods for determining the water quality component of the Ecological Reserve. Report prepared for Department of Water Affairs and Forestry, Pretoria, South Africa by P-A Scherman. Draft 2, March 2008.

The methodology used for the determination of the **ground**water component of the ecological reserve is that set out in *DWAF (1999): Resource Directed Measures for Protection of Water Resources; Volume 6: Ground Water Component Version 2.0.*

Resource Category

The methodology for preliminary determination of the water resource category is part of the methodology referenced in *DWAF (1999): Resource Directed Measures for Protection of Water Resources; Volume 3: River Ecosystems Version 1.0.*

Basic Human Needs Reserve

The **quantity** component of the basic human needs Reserve was calculated from population water requirements provided by Chief Directorate: Water Services, Directorate: Community Water Planning. The population figures used were based on the 1991 census and extensive field verification project initiated in 1994. The **average population for quaternary catchment B41H** was used. This component of the Reserve has been accounted for in the surface water quantity component of the Reserve.

The water **quality** component of the basic human needs Reserve was determined using:

Quality of Domestic Water Supplies, Volume 1: Assessment Guide, 2nd Ed. 1998. Water Research Commission Report No: TT101/98. Pretoria, South Africa, and *South African Water Quality Guidelines, Volume 1: Domestic Water Use, 2nd Ed.* 1996. Department of Water Affairs and Forestry, Pretoria, South Africa

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and Forestry, Pretoria.

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Department of Water Affairs and Forestry 2008b. Operationalise the Reserve: Main Report. Compiled by: Louw D. and S Louw. Report No. RDM/NAT/05/CON/0907. Department of Water Affairs and Forestry, Pretoria.

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