Water Resource Planning
Systems Series

SUB-SERIES NO. WQP 1.7.2.1

Resource Directed Management of Water Quality

MANAGEMENT INSTRUMENTS

Volume 4.2.1

Users' Guide

Resource Water Quality Objectives (RWQO) Model (Version 4.0)

August 2006
Edition 2

water & forestry

Department:
Water Affairs & Forestry
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DEPARTMENT OF WATER AFFAIRS AND FORESTRY

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Co-ordinated by:
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Reports as part of this project:

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1.3	Appendix E: Project Document. Glossary of terminology often used in the Resource Directed Management of Water Quality
1.4	Volume 1: *Policy Document Series*
1.4.1	Volume 1.1: Summary Policy
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1.7.6	Introduction

Bold type indicates this report.

*These reports are internal project management documents that are not available for publication.
**These reports are earlier versions that have been improved upon in the second edition and thus are not available for publication.
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APPROVAL

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DATE: August 2006

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ACRONYMS

AEMC	Attainable Ecological Management Class
DWAF	Department of Water Affairs & Forestry
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RWQOs	Resource Water Quality Objectives
WRC	Water Research Commission

SUPPORT

For enquiries please contact the:
Department of Water Affairs and Forestry,
Tel (012) 336-7500 or Fax (012) 336-7044

Further supporting documentation may be obtained from
http://www.dwaf.gov.za/

Developed for the Department of Water Affairs and Forestry by the

1. System

This guide provides assistance to users of the software package (RWQO Model vs. 4.0) for the determination of Resource Water Quality Objectives (RWQOs) for surface water resources. For detail on the methodology behind this system, the user is referred to the "Guideline for determining Resource Water Quality Objectives (RWQOs), Allocatable Water Quality and the Stress of the Water Resource" (DWAF, 2006), accessible from within the Model or on the enclosed CD. The software is freely available from the Department of Water Affairs and Forestry.

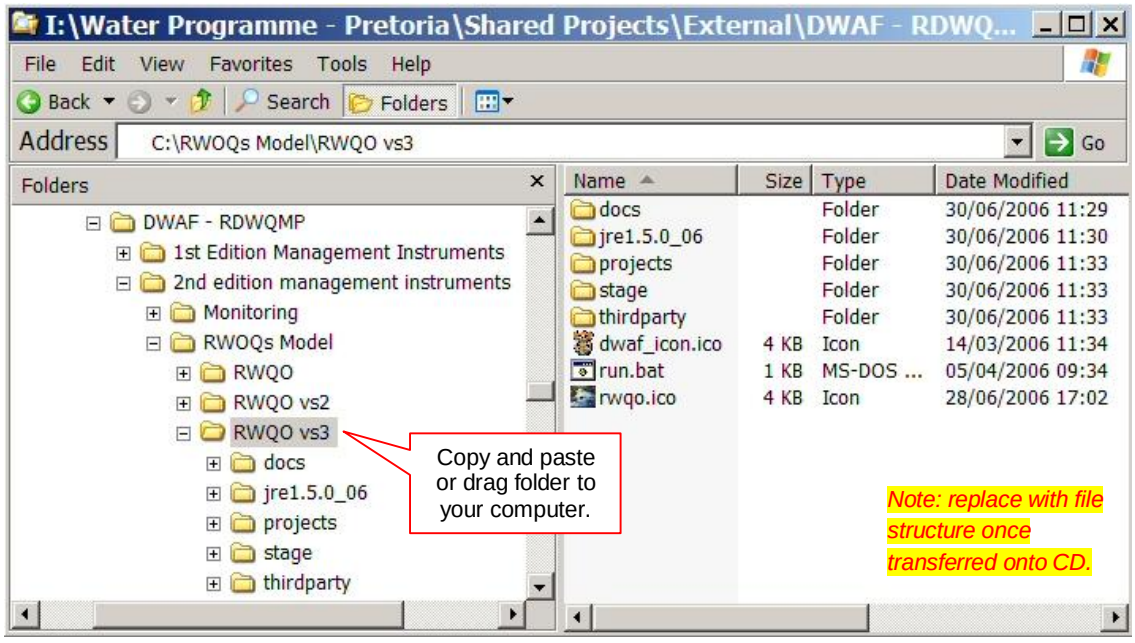
2. Setup

■ Software Version

This Users Guide is applicable to version 4.0 of the RWQOs Model, developed by the CSIR for the Department of Water Affairs and Forestry (DWAF).

■ Setting up

The RWQOs Model is a computer-based application which can be run either from the setup CD or from a computer. To run the Model from the CD locate and open the file run.bat. To run the Model from the computer, the user should copy the relevant folder and associated files from the CD and paste them into a folder created for the application.



The Model is a standalone application and requires no additional software to run. Should users wish to open any of the available documents within the Model [See Functions], they will need Acrobat Reader. The setup file for Acrobat Reader is enclosed on the attached CD or can be downloaded from www.adobe.com.

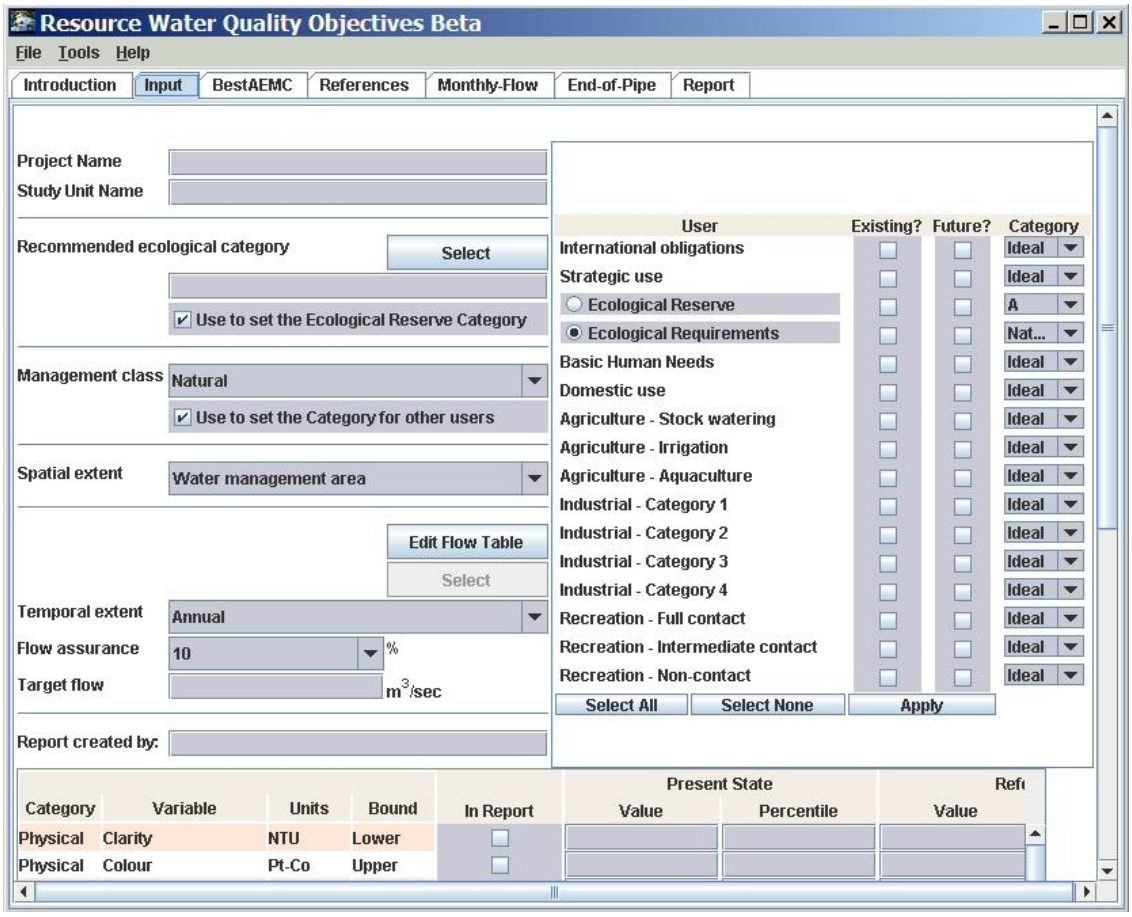
3. System Requirements

There are no specific system requirements to operate the RWQOs Model.

4. Quick Start

What you need to know and do to get started:

1. Copy the folder from the CD to your computer
2. Locate and Open the file run.bat
3. You are now ready to begin a new project, or an existing saved project.



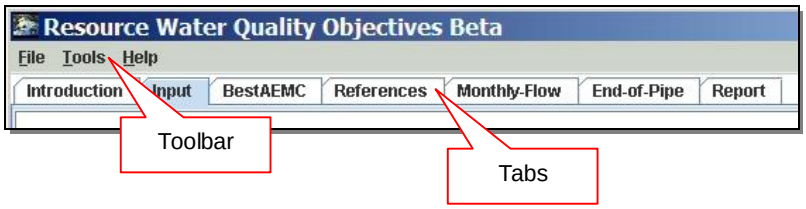
5. Overview

The RWQOs Model (vs 4.0) provides users with a standard approach to consistently setting Resource Water Quality Objectives (RWQOs) for surface water resources in South Africa. By selecting the water resource and user requirements, the Model generates RWQOs that are based on a database of provided and entered water quality parameters.

The Model provides a quick approach to setting RWQOs based on the guidelines for determining Resource Water Quality Objectives (RWQOs), Allocatable Water Quality and the Stress of the Water Resource (DWAF, 2006).

6. Functions

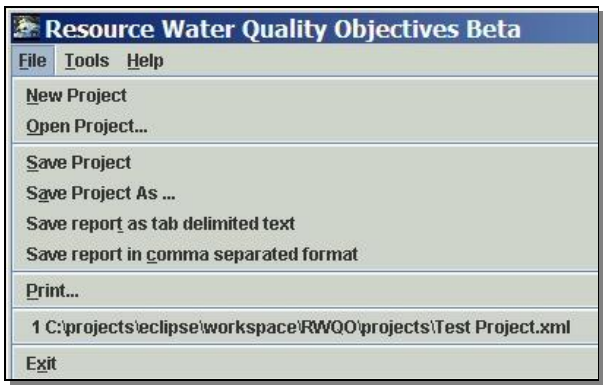
The Model provides two levels of functions; these are accessible through the Toolbar and through the Tabs.



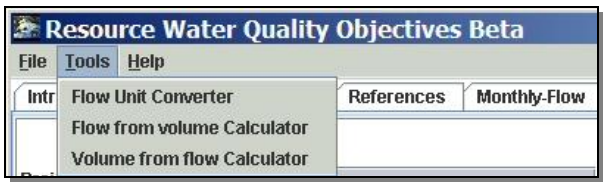
■ Toolbar

Toolbar options include:

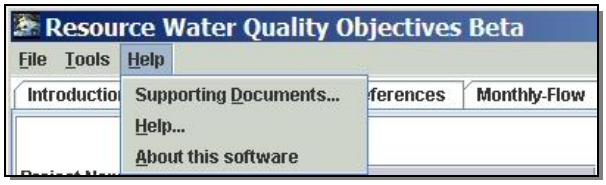
- **File**
- **Tools**
- **Help**



The 'File' dropdown menu on the toolbar, allows users to create a new project, open an already saved project, save a project, save a report, or print a report**.**



The 'Tools' dropdown menu on the toolbar, allows users to easily convert a number of flow units into the required flow format of m^3/s and vice versa.



The 'Help' dropdown menu on the toolbar, allows users to access supporting documents, e.g. guidelines, legislation; access to on-line help; and information about the software version.

■ Tabs

The 'Tabs' provide an overview of each of the working screens in the Model, namely:

- **Introduction**
- **Input**
- **Best AEMC**
- **References**
- **Monthly-Flow**
- **End-of-Pipe**
- **Report**

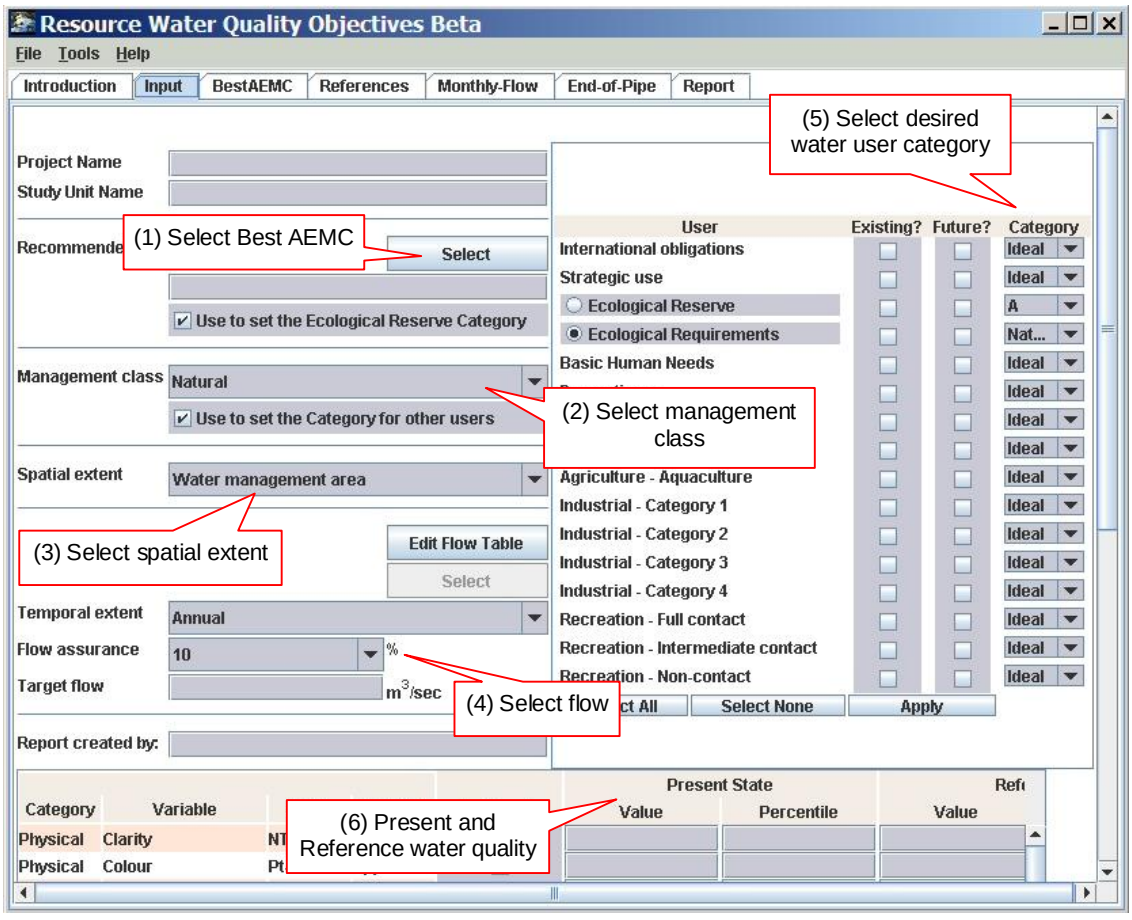
♦ Introduction

The 'Introduction' tab provides users with a brief overview and background to the Model.

♦ Input

The 'Input' tab is the main input screen in the Model. Here users are required to:

1) Select (or enter) the Recommended Ecological Category (Best AEMC) for the water resource management unit;
2) Select the desired management class for the water resource management unit;
3) Set the spatial extent of the water resource management unit;
4) Select the desired target flows to support the determination of loads;
5) Select the desired water user categories (current and future); and
6) Enter present and reference water quality for selected parameters of concern.

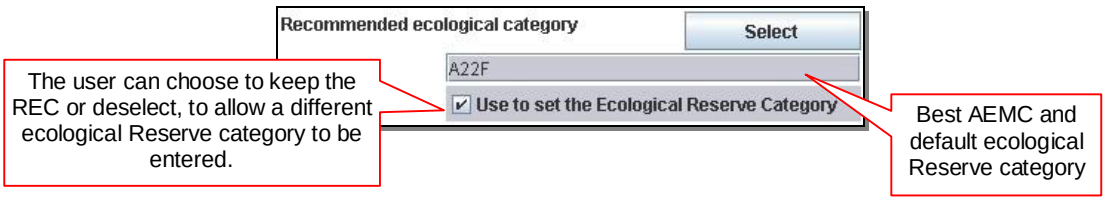


Each of these steps is briefly unpacked below.

v Recommended ecological category

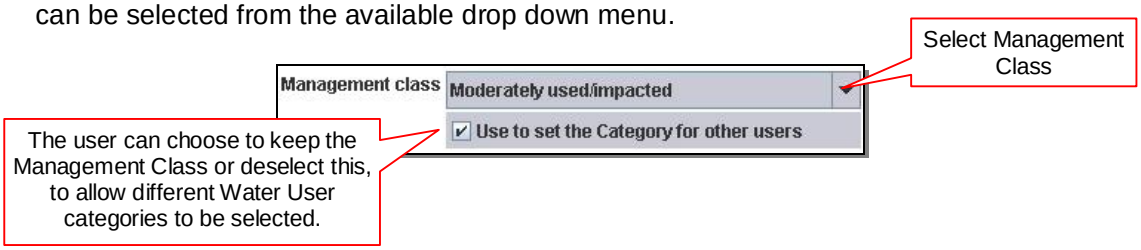
The Recommended ecological category (REC) (sourced from the Best AEMC) provides the starting default category for the ecological Reserve category [*under Users*]. To select the REC the user should go to the BestAEMC tab and select the appropriate quaternary catchment. By doing so, the Best AEMC will automatically be filled into the Input screen.

Select REC



v Desired management class

The Management Class, for the water resource management unit, provides the starting or default category for the other Water Users [*under Users*] - [Natural=Ideal; Moderately used/impacted=Acceptable; Heavily used/impacted=Tolerable]. The Management Class can be selected from the available drop down menu.

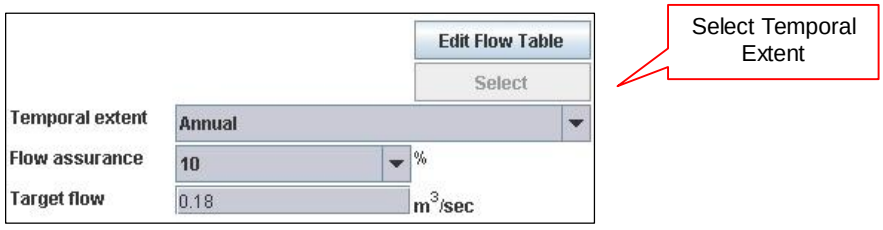


v Spatial extent of the water resource management unit

The spatial extent defines the water resource management unit for the study. This is used for supporting information and is not used in any of the calculations to determine the RWQOs.

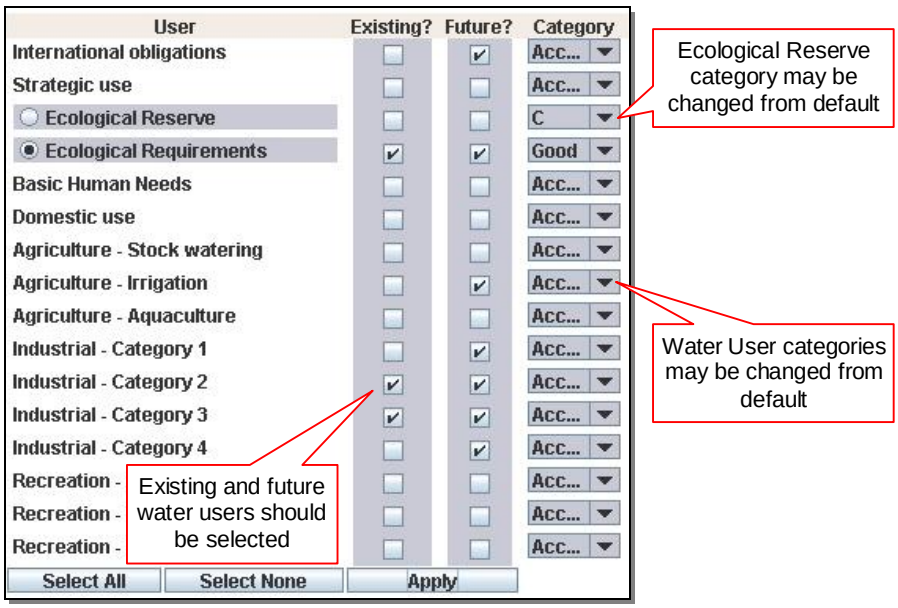
v Target flows and flow assurance

The flow is used in the Model to determine the allocatable load and the end-of-pipe discharges. Once flows have been entered in the Monthly-Flow tab, the desired temporal extent and flow assurance should be selected. This will automatically insert the target flow into the required field. Flows may be edited by clicking on the Edit Flow Table button.



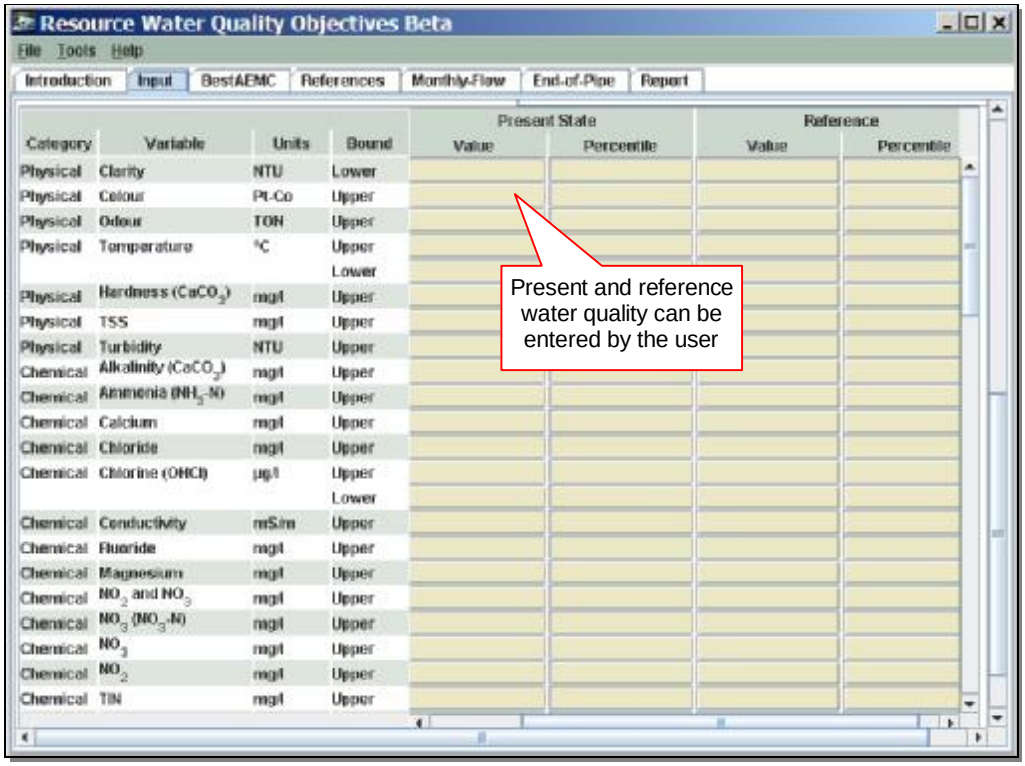
v Desired water user categories (current and future)

The desired water user categories, both existing and future are fundamental to determining the RWQOs.



v Present and reference water quality for selected parameters of concern

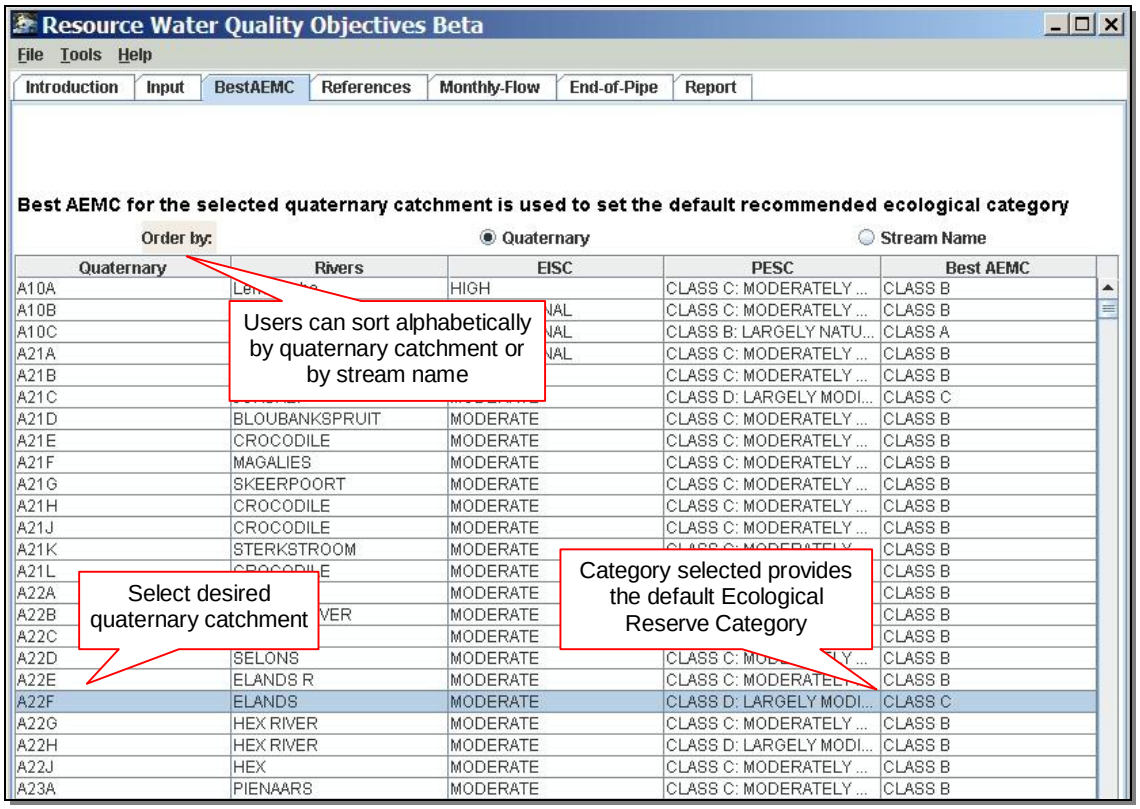
The present water quality is used to determine the water resource stress [*See Reports*], while the reference water quality provides data to assess the feasibility of the determined RWQOs.



♦ Best AEMC

The 'Best Achievable Ecological Management Category (Best AEMC)' tab allows users to automatically select the *Recommended Ecological Category* for a given quaternary

catchment. The Best AEMC was determined by specialists with local knowledge of the various catchments (Kleynhans, 1999).



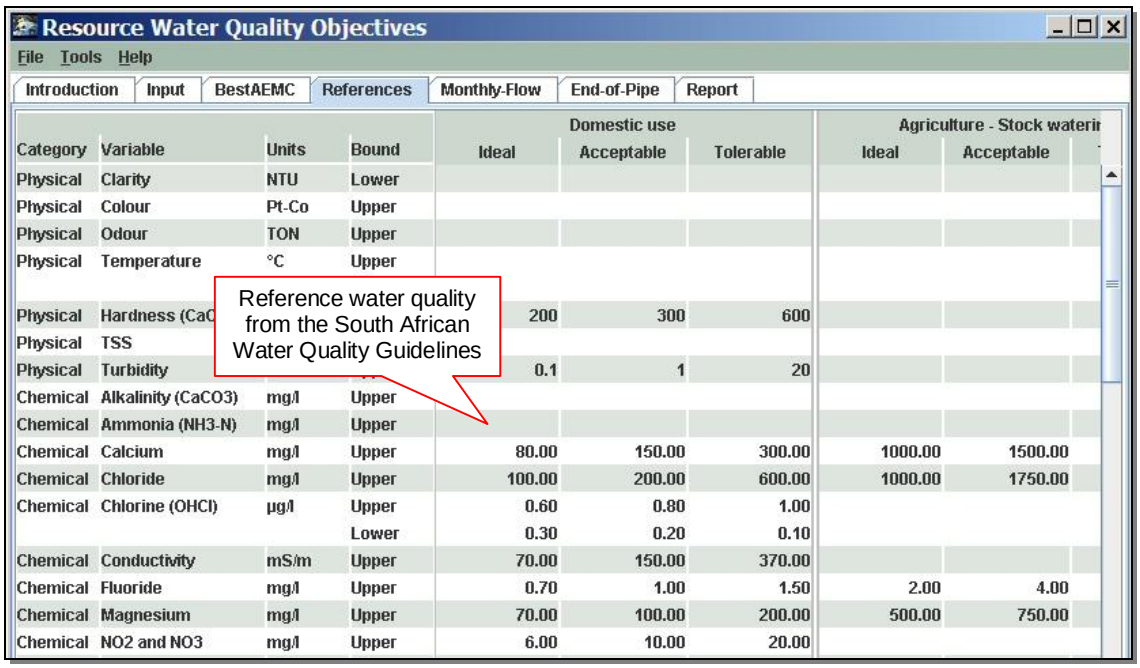
Quaternary	Rivers	EISC	PESC	Best AEMC
A10A		HIGH	CLASS C: MODERATELY ...	CLASS B
A10B			CLASS C: MODERATELY ...	CLASS B
A10C			CLASS B: LARGELY NATU...	CLASS A
A21A			CLASS C: MODERATELY ...	CLASS B
A21B			CLASS C: MODERATELY ...	CLASS B
A21C			CLASS D: LARGELY MODI...	CLASS C
A21D	BLOUBANKSPRUIT	MODERATE	CLASS C: MODERATELY ...	CLASS B
A21E	CROCODILE	MODERATE	CLASS C: MODERATELY ...	CLASS B
A21F	MAGALIES	MODERATE	CLASS C: MODERATELY ...	CLASS B
A21G	SKEERPOORT	MODERATE	CLASS C: MODERATELY ...	CLASS B
A21H	CROCODILE	MODERATE	CLASS C: MODERATELY ...	CLASS B
A21J	CROCODILE	MODERATE	CLASS C: MODERATELY ...	CLASS B
A21K	STERKSTROOM	MODERATE		CLASS B
A21L		MODERATE		CLASS B
A22A		MODERATE		CLASS B
A22B		MODERATE		CLASS B
A22C		MODERATE		CLASS B
A22D	SELONS	MODERATE		CLASS B
A22E	ELANDS R	MODERATE	CLASS C: MODERATELY ...	CLASS B
A22F	ELANDS	MODERATE	CLASS D: LARGELY MODI...	CLASS C
A22G	HEX RIVER	MODERATE	CLASS C: MODERATELY ...	CLASS B
A22H	HEX RIVER	MODERATE	CLASS D: LARGELY MODI...	CLASS B
A22J	HEX	MODERATE	CLASS C: MODERATELY ...	CLASS B
A23A	PIENAARS	MODERATE	CLASS C: MODERATELY ...	CLASS B

♦ References

The 'Reference tab' provides the input water quality data for various water user types, and is used to determine the RWQOs. For certain water users, the water quality data are automatically provided in the Model [Reference tab], based on the South African Water Quality Guidelines (DWAF, 1996) (e.g. Domestic Use, Agriculture, Industrial, and Recreation) – these are accessible under Help > Supporting Documents. In addition, default water quality data are provided for Ecological Requirements (in the absence of an ecological reserve) (Palmer *et al.*, 2005) and Basic Human Needs (Class 1) (WRC, 1998).

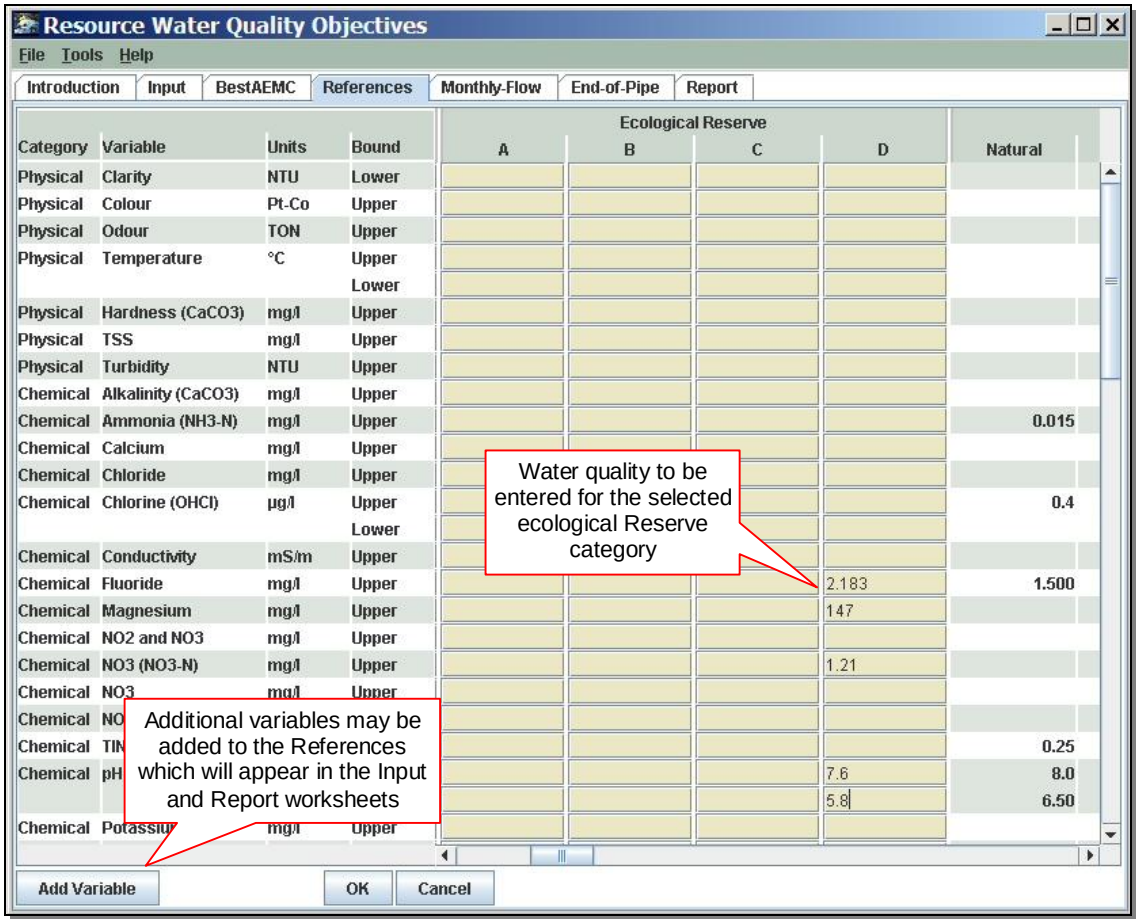
If applicable to the catchment, users are required to enter the water quality in the 'Reference' tab for:

- International obligations;
- Strategic use; and
- Ecological Reserve.



Category	Variable	Units	Bound	Domestic use Ideal	Domestic use Acceptable	Domestic use Tolerable	Agriculture - Stock waterir Ideal	Agriculture - Stock waterir Acceptable
Physical	Clarity	NTU	Lower					
Physical	Colour	Pt-Co	Upper					
Physical	Odour	TON	Upper					
Physical	Temperature	°C	Upper					
Physical	Hardness (CaC			200	300	600		
Physical	TSS							
Physical	Turbidity			0.1	1	20		
Chemical	Alkalinity (CaCO3)	mg/l	Upper					
Chemical	Ammonia (NH3-N)	mg/l	Upper					
Chemical	Calcium	mg/l	Upper	80.00	150.00	300.00	1000.00	1500.00
Chemical	Chloride	mg/l	Upper	100.00	200.00	600.00	1000.00	1750.00
Chemical	Chlorine (OHCl)	µg/l	Upper	0.60	0.80	1.00		
			Lower	0.30	0.20	0.10		
Chemical	Conductivity	mS/m	Upper	70.00	150.00	370.00		
Chemical	Fluoride	mg/l	Upper	0.70	1.00	1.50	2.00	4.00
Chemical	Magnesium	mg/l	Upper	70.00	100.00	200.00	500.00	750.00
Chemical	NO2 and NO3	mg/l	Upper	6.00	10.00	20.00		

The ecological Reserve water quality data are entered for the selected ecological Reserve category, as determined from the Reserve process.



Category	Variable	Units	Bound	Ecological Reserve A	B	C	D	Natural
Physical	Clarity	NTU	Lower					
Physical	Colour	Pt-Co	Upper					
Physical	Odour	TON	Upper					
Physical	Temperature	°C	Upper					
			Lower					
Physical	Hardness (CaCO3)	mg/l	Upper					
Physical	TSS	mg/l	Upper					
Physical	Turbidity	NTU	Upper					
Chemical	Alkalinity (CaCO3)	mg/l	Upper					
Chemical	Ammonia (NH3-N)	mg/l	Upper					0.015
Chemical	Calcium	mg/l	Upper					
Chemical	Chloride	mg/l	Upper					
Chemical	Chlorine (OHCl)	µg/l	Upper					0.4
			Lower					
Chemical	Conductivity	mS/m	Upper					
Chemical	Fluoride	mg/l	Upper				2.183	1.500
Chemical	Magnesium	mg/l	Upper				147	
Chemical	NO2 and NO3	mg/l	Upper					
Chemical	NO3 (NO3-N)	mg/l	Upper				1.21	
Chemical	NO3	mg/l	Upper					
Chemical	NO							
Chemical	TIN							0.25
Chemical	pH						7.6	8.0
							5.8	6.50
Chemical	Potassiu	mg/l	Upper					

There is no ecological Reserve?

If an Ecological Reserve has not been set for the water resource management unit, the Model will automatically use the 'Ecological Requirements' (Palmer *et al.*, 2005) for the default Ecological Reserve Category, as determined from the Best AEMC.

♦ Monthly Flow

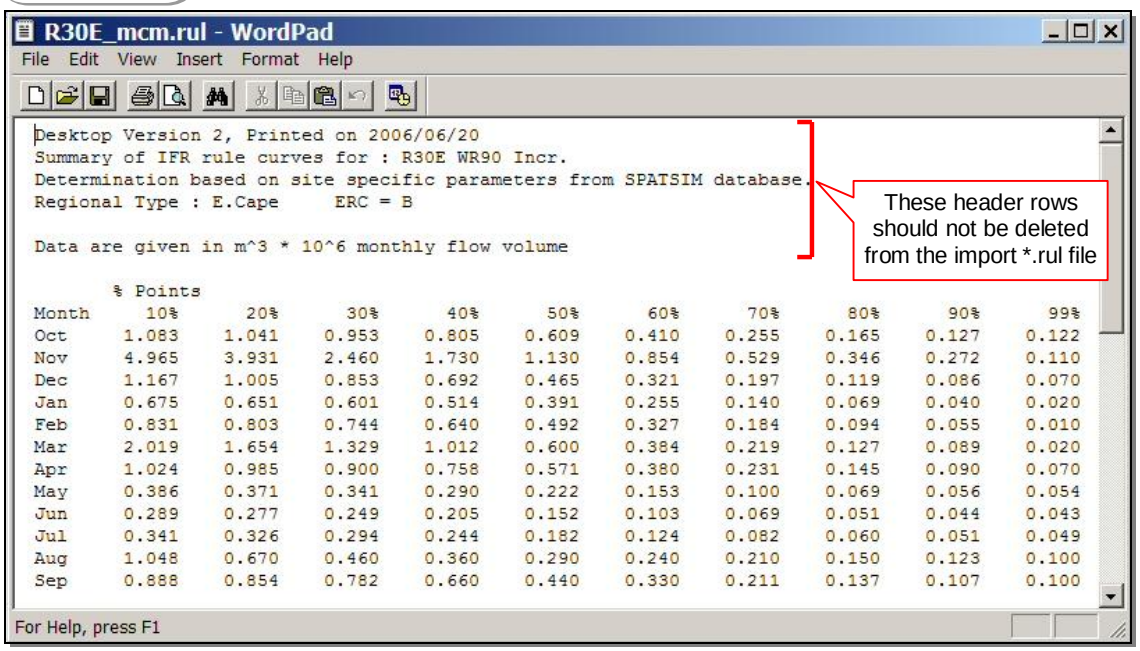
Target flows and flow assurances are used to set the 'Allocatable Load', i.e. the water quality over and above that required for the RWQOs, i.e. that which can be allocated for use.

The flows are entered into the 'Monthly Flow' tab. This can be done in two possible ways, either by:

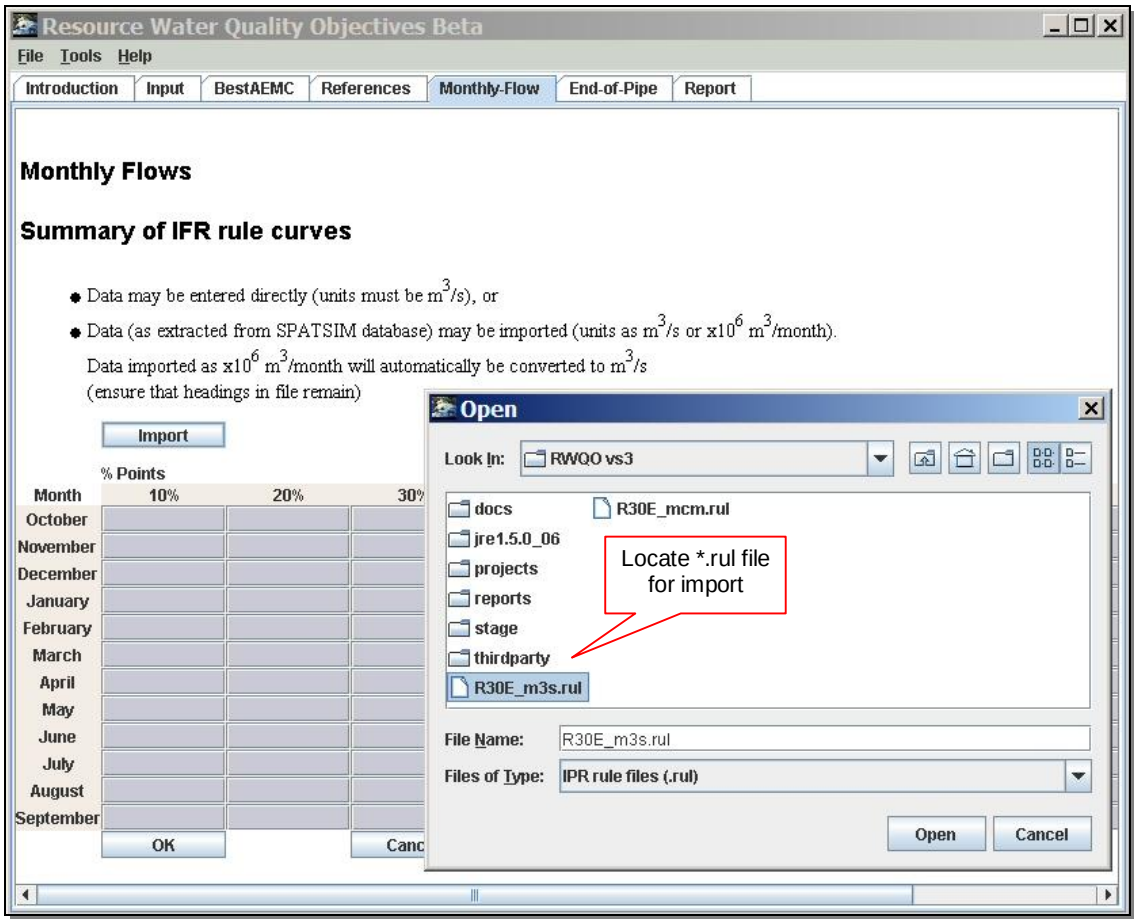
- Typing the monthly flows into a given flow assurance column, e.g. 10%, or
- Importing the monthly flows as derived from the SPATSIM database (*.rul file), i.e. the output of the Reserve process.

What units should the flows be in?

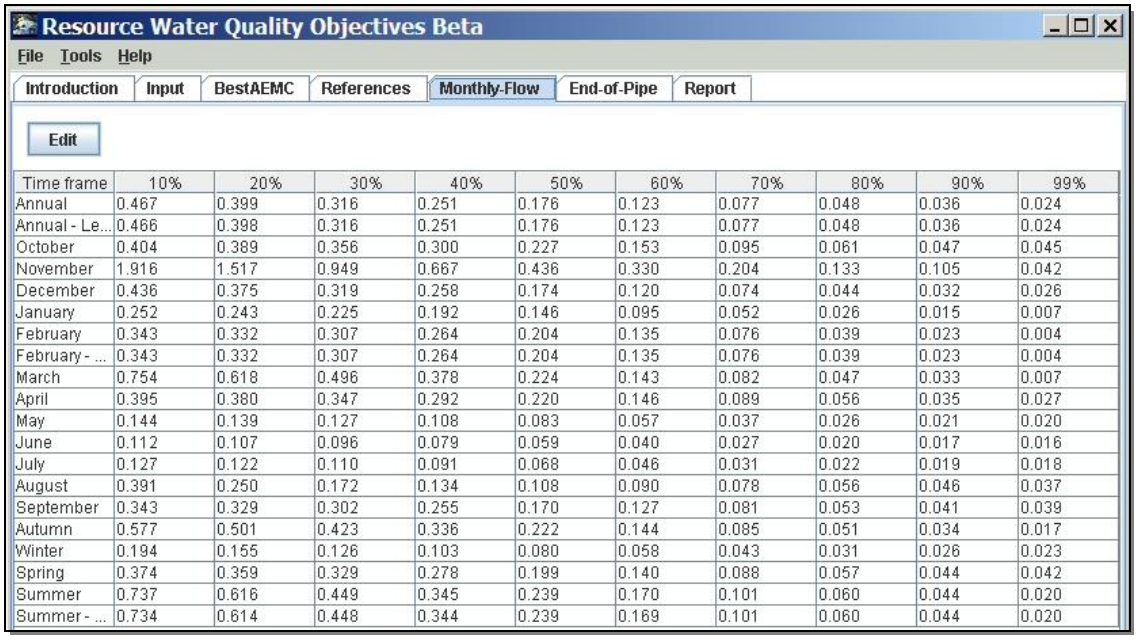
The monthly flows can be imported as either m^3/s or Mm^3/month. If the SPATSIM *.rul file is being imported, it is important that the header rows remain in the file. The Model will read these lines, to determine the import flow units.



To import flow data, click the Import button in the 'Monthly-Flow' tab. This will take users to an 'Open' screen where you can locate the file for import.



Once imported, the 'Monthly-Flow' tab will be populated with flow assurance values to be used in the Input Tab.



Time frame	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Annual	0.467	0.399	0.316	0.251	0.176	0.123	0.077	0.048	0.036	0.024
Annual - Le...	0.466	0.398	0.316	0.251	0.176	0.123	0.077	0.048	0.036	0.024
October	0.404	0.389	0.356	0.300	0.227	0.153	0.095	0.061	0.047	0.045
November	1.916	1.517	0.949	0.667	0.436	0.330	0.204	0.133	0.105	0.042
December	0.436	0.375	0.319	0.258	0.174	0.120	0.074	0.044	0.032	0.026
January	0.252	0.243	0.225	0.192	0.146	0.095	0.052	0.026	0.015	0.007
February	0.343	0.332	0.307	0.264	0.204	0.135	0.076	0.039	0.023	0.004
February - ...	0.343	0.332	0.307	0.264	0.204	0.135	0.076	0.039	0.023	0.004
March	0.754	0.618	0.496	0.378	0.224	0.143	0.082	0.047	0.033	0.007
April	0.395	0.380	0.347	0.292	0.220	0.146	0.089	0.056	0.035	0.027
May	0.144	0.139	0.127	0.108	0.083	0.057	0.037	0.026	0.021	0.020
June	0.112	0.107	0.096	0.079	0.059	0.040	0.027	0.020	0.017	0.016
July	0.127	0.122	0.110	0.091	0.068	0.046	0.031	0.022	0.019	0.018
August	0.391	0.250	0.172	0.134	0.108	0.090	0.078	0.056	0.046	0.037
September	0.343	0.329	0.302	0.255	0.170	0.127	0.081	0.053	0.041	0.039
Autumn	0.577	0.501	0.423	0.336	0.222	0.144	0.085	0.051	0.034	0.017
Winter	0.194	0.155	0.126	0.103	0.080	0.058	0.043	0.031	0.026	0.023
Spring	0.374	0.359	0.329	0.278	0.199	0.140	0.088	0.057	0.044	0.042
Summer	0.737	0.616	0.449	0.345	0.239	0.170	0.101	0.060	0.044	0.020
Summer - ...	0.734	0.614	0.448	0.344	0.239	0.169	0.101	0.060	0.044	0.020

Where do I get monthly flows?

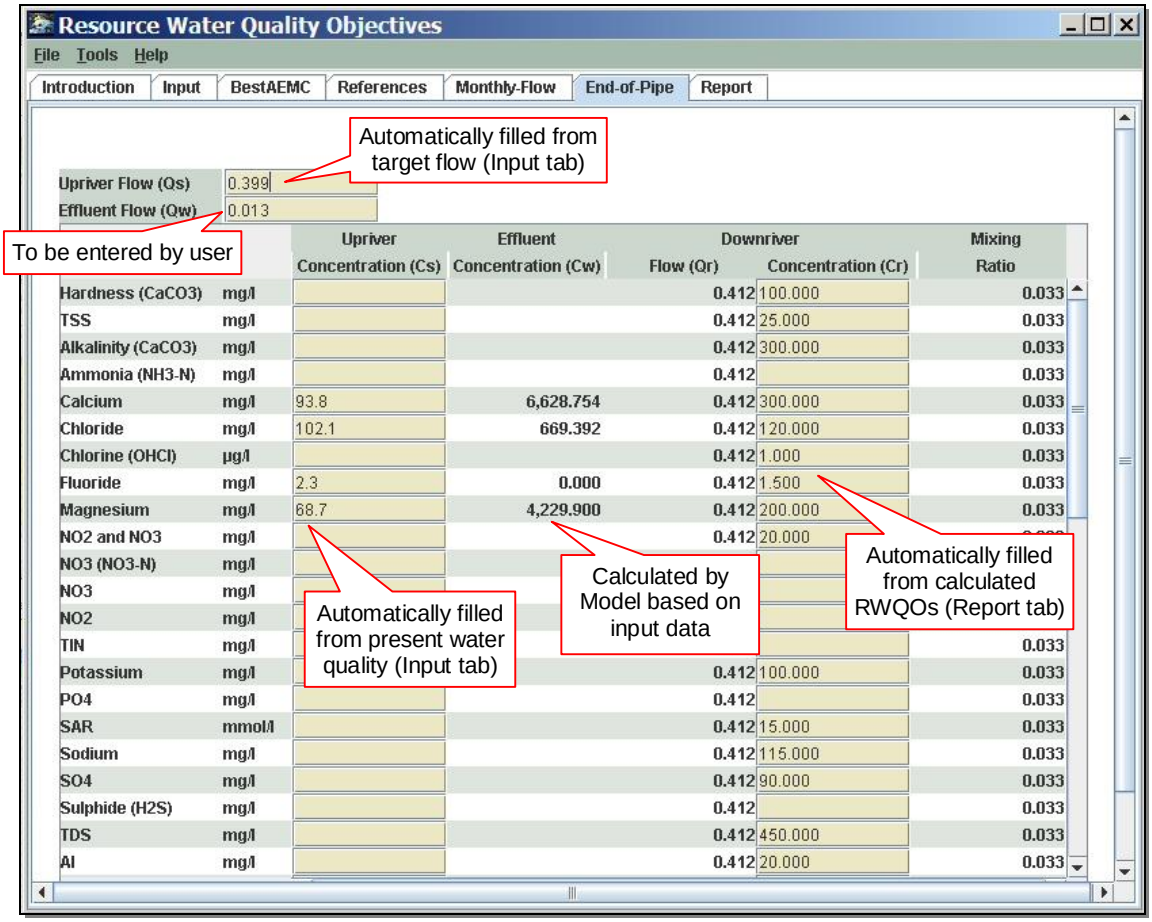
Monthly flow data are sourced from the SPATSIM database, obtainable from the Chief Directorate RDM. Flows should be requested for the point or catchment for which the RWQOs are being set.

How do I edit flows after I have imported them?

If you need to edit the monthly flows after having imported the *.rul file, you can do this by clicking on the Edit Flow Table button in the 'Input' tab or by clicking on the Edit button in the Monthly-Flow tab.

♦ End-of-pipe

The 'End-of-Pipe' tab, allows users to work back to point source effluent discharges, to determine the end-of-pipe discharge(s) that may be allowed in order to achieve the RWQOs. The 'End-of-Pipe' tab makes use largely of data that have already been entered within the other tabs. The only data to be entered in the 'End-of-Pipe' tab are the data for 'Effluent Flow'.



		Upriver Concentration (Cs)	Effluent Concentration (Cw)	Downriver Flow (Qr)	Downriver Concentration (Cr)	Mixing Ratio
Hardness (CaCO3)	mg/l			0.412	100.000	0.033
TSS	mg/l			0.412	25.000	0.033
Alkalinity (CaCO3)	mg/l			0.412	300.000	0.033
Ammonia (NH3-N)	mg/l			0.412		0.033
Calcium	mg/l	93.8	6,628.754	0.412	300.000	0.033
Chloride	mg/l	102.1	669.392	0.412	120.000	0.033
Chlorine (OHCl)	µg/l			0.412	1.000	0.033
Fluoride	mg/l	2.3	0.000	0.412	1.500	0.033
Magnesium	mg/l	68.7	4,229.900	0.412	200.000	0.033
NO2 and NO3	mg/l			0.412	20.000	
NO3 (NO3-N)	mg/l					
NO3	mg/l					
NO2	mg/l					
TIN	mg/l					0.033
Potassium	mg/l			0.412	100.000	0.033
PO4	mg/l			0.412		0.033
SAR	mmol/l			0.412	15.000	0.033
Sodium	mg/l			0.412	115.000	0.033
SO4	mg/l			0.412	90.000	0.033
Sulphide (H2S)	mg/l			0.412		0.033
TDS	mg/l			0.412	450.000	0.033
Al	mg/l			0.412	20.000	0.033

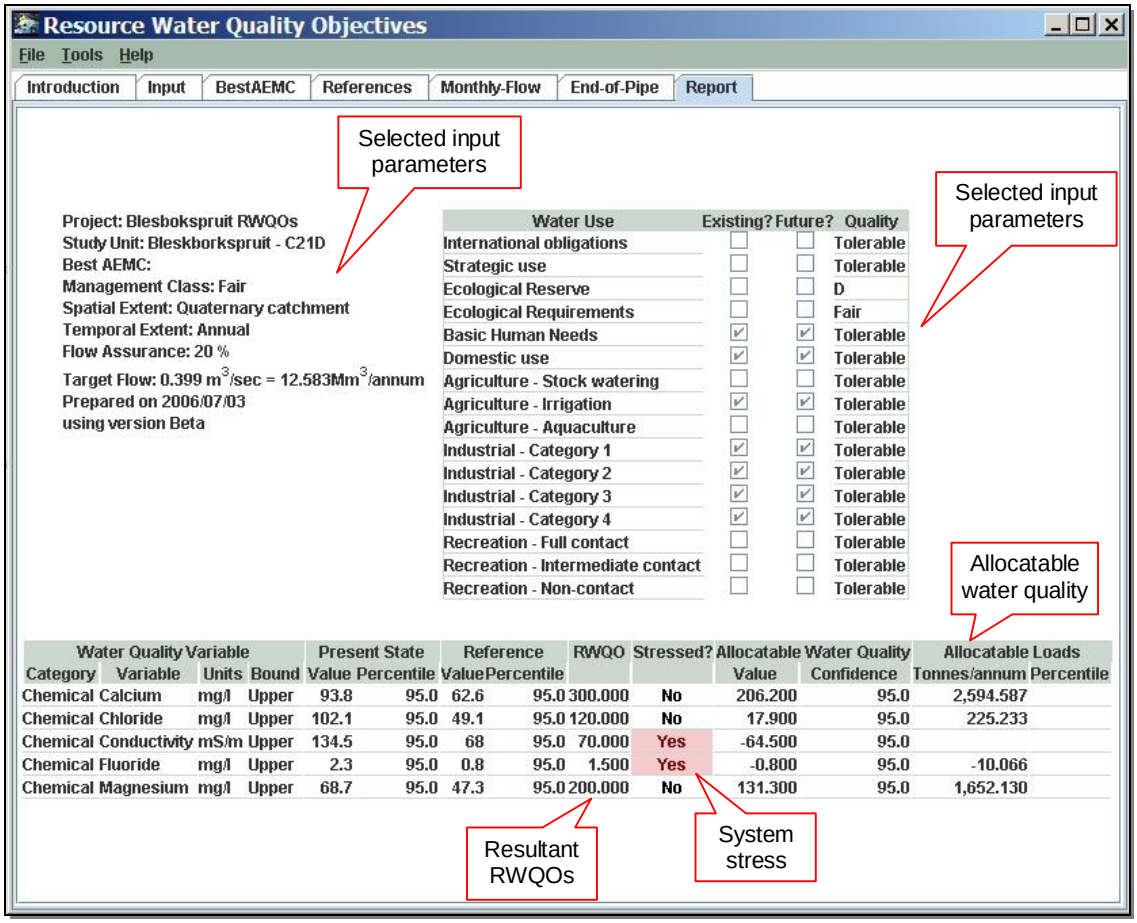
Effluent Concentration (Cw)

The Effluent Concentration (Cw) calculated in the Model is the total allocatable effluent quality – this may be assigned to a single user or to multiple users. It is up to the user to determine how the effluent concentration will be assigned within a catchment or river reach.

♦ Report

Having entered all of the necessary data into the input screen, the user may view the results in the 'Report' tab. The report provides a:
(1) review of the present and reference water quality, and
(2) results of:

- RWQOs;
- Resource stress;,
- The allocatable water quality and associated confidence; and
- The allocatable loads.



Parameters of Concern

For the RWQOs of a particular variable to appear in the 'Report' tab, that variable must have been selected in the 'Input' tab as a parameter of concern. This should be done by ☑ the required variable.

How are the RWQO determined by the Model?

The Model determines the RWQOs by selecting the lowest or most sensitive water quality, for each variable of concern, for each selected water user (existing and future). The water quality requirements are extracted from entered water quality data (Reserve, International Obligations, Strategic Use) and default SA Water Quality Guideline data.

How is Stress determined by the Model?

The stress of the resource is the difference between the proposed RWQOs and the present water quality.

RWQOs > Present = unstressed (water quality available for allocation)

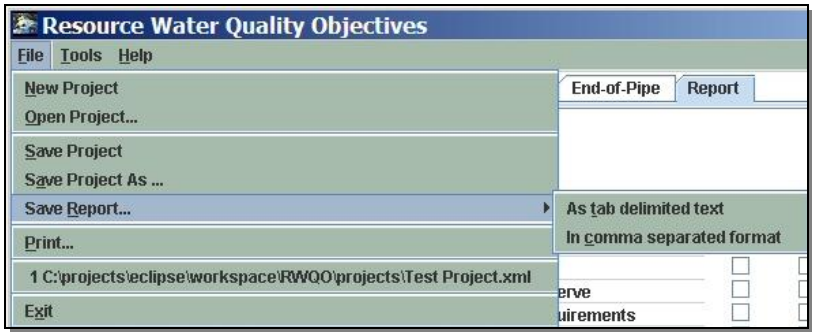
RWQOs < Present = stressed (no water quality available for allocation)

Saving and Exporting the results

Reports that have been generated for a project can be saved or printed, allowing users to modify input criteria and assess the impact of these changes on the resultant RWQOs.

The results can be exported as either *'tab delimited text*' or in '*comma separated format*'. The '*tab delimited text*' option allows users to open the report in e.g. Notepad, MS Word, WordPerfect, while the '*comma separated format*' allows users to open the report in e.g. MS Excel.

To export or save the report, go to >> File >> Save Report. Select either 'As tab delimited text' or 'In comma separated format'.



7. Data requirements

To determine RWQOs, the Model requires the following input data:

- Ecological category – from a Reserve or Best AEMC
- Management Class – from a catchment visioning exercise
- Target flows – from Reserve output - *.rul files
- Existing and future water users within the water resource management unit
- Present water quality – 5th and 95th percentiles
- Reference water quality – 5th and 95th percentiles

8. References

Department of Water Affairs and Forestry (DWAF), 1996. *South African Water Quality Guidelines. Volumes 1-7*. Pretoria, South Africa.

Department of Water Affairs and Forestry (DWAF), 2006. *Guideline for determining Resource Water Quality Objectives (RWQOs), Allocatable Water Quality and the Stress of the Water Resource*. Edition 2. Water Resource Planning Systems Series, Sub-Series No. WQP 1.7.2. Pretoria, South Africa.

Kleynhans, C.J., 1999. *Desktop Level Estimate of Ecological Management Classes for the Quantity Component of the Ecological Reserve for use in the National Water Balance Model*. Unpublished Report.

Palmer, C.G., Rossouw, N., Muller, W.J. and Scherman, P.A, 2005. *The development of water quality methods within ecological Reserve assessments, and links to environmental flows*. *Water SA*, **31** (2): 161-170.

Water Research Commission (WRC), 1998. *Quality of Domestic Water Supplies, Volume 1: Assessment Guide, 2nd Ed.* Water Research Commission Report No: TT 101/98. Pretoria, South Africa.

9. Index by Keyword

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