REFINEMENT OF THE REVISED DESKTOP RESERVE MODEL

VOLUME 2: RDRM REFINEMENT: MANUAL

D Birkhead, D Hughes, P Kotze, D Louw, J Mackenzie

WRC Report No. 2539/2/19
ISBN 978-0-6392-0425-3

August 2019

WATER
RESEARCH
COMMISSION

Obtainable from
Water Research Commission
Private Bag X03
Gezina
PRETORIA, 0031

orders@wrc.org.za or download from www.wrc.org.za

This report forms part of a set of two reports. The other report is Refinement of the Revised Desktop Reserve Model. Volume 1: RDRM Refinement: Background and Description (WRC Report No. 2539/1/19).

ACKNOWLEDGEMENTS

The following DWS trainees are acknowledged for the input provided in testing and reviewing the manual.

Ms Tinyiko Mpete
Ms Gladys Makhado
Mr Molefi Mazibuko

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

The objective is to provide a manual that can be used by desktop users and specialists.

1.1 MANUAL STRUCTURE

The manual was developed in phases as follows:

- First draft aimed at only the desktop user.
- A testing of the draft by desktop users (DWS RDRM trainees).
- Refinement of the manual to incorporate comments.
- Addition to the manual aimed towards specialist use of the model – i.e. to demonstrate how and where specialists can input specialist knowledge based on detailed information.
- Finalisation of the manual.

The format of the manual will be a Word document which will include figures illustrating different screens or pages of SPATSIM and RDRM which will be annotated with notes (information blocks not numbered) and instructions (information blocks with numbers representing the chronological sequence of steps). Each figure will be further supported by explanatory notes where necessary. The screen dumps and annotations will be done in Powerpoint and copied from there into the word document. The Powerpoints will also be available in .pptx format to allow users to adjust and make notes as they see fit, i.e. to personalise the manual.

This manual will be based on the available RDRM_SPATSIM_guide.pptx which is available on line and authored and updated by Prof Hughes, IWR, Rhodes University. The manual will include both a manual for SPATSIM (Ver 3) as well as the RDRM within SPATSIM. Note that the SPATSIM component of this manual only focusses on the components of SPATSIM that are required to run the RDRM within SPATSIM. Further information on SPATSIM and its many uses are available on the IWR website of Rhodes University.

Chapter two to 13 focuses on the manual for the desktop application of the RDRM and are structured as follows:

- Chapter two provides the manual on SPATSIM in general
- The rest of the chapters follow the process both in SPATSIM and then in RDRM of what one needs to do to set up a EWR site and then run the RDRM to produce results.

Chapter 14 to the end focuses on the manual for the application of the RDRM for uses other than desktop, i.e. for intermediate or comprehensive applications of the Reserve. The focus is on identifying where and how data and specialist input can be incorporated into the model.

Note: This manual cannot be used as a manual on how to determine EWRs or to explain concepts of EWRs. The manual is based on the assumption that:

- Desktop users understand the basic concepts of EWRs
- Specialist users are comfortable determining EWRs using standard methods.

1.2 INSTALL AND OR UPGRADE INSTRUCTIONS

Software is available at:
http://www.ru.ac.za/iwr/research/spatsim/
Download these files:

- SPATSIM_V3R5.exe the software installer (11 Dec 2017)

- NationalV2_01.exe – the example database installer that includes all the data for using the Revised Desktop Reserve Model (RDRM) for South Africa.

Installing:

- Save the above files.
- Find the file you saved on your computer (wherever your browser puts downloads)
- RIGHT click the SPATSM_V3Rx.exe file and select *'run as administrator'* to install it.
- Double click the NationalV2_xx.exe file to install it. (If you already have such a project you will need to rename the *nationalv2.sqlite3* file in order for this version to install as the installer will not overwrite an existing file that is newer than the install file).

Notes:

Sometimes Windows overrides the default install destination of C:\SPATSIM_V3 and installs to a different drive. If it installs to a different drive (say X), then you can either drag and drop X:\SPATSIM_V3 to C:\SPATSIM_V3 OR open the *.ini files in X:\SPATSIM_V3 and replace C: with X: open the X:\SPATSIM_V3\tsoft.ini file and replace C: with X: thus allowing SPATSIM to run from the X drive. New projects will not require modification.

Moving between C: and another drive:

The installer defaults to installing on C: drive.

If you need to run SPATSIM from another drive you can use the mover tool.

- Open File Explorer
- Navigate to C:\SPATSIM_V3\bin
- double click the 'spmove.exe' program
- Select the destination drive
- Click the Move button

Note that after this process your desktop icon will not work until you tell it where to find SPATSIM.EXE on the new drive.

Regional Settings

Make sure your regional settings specifies a point (**.**) for the decimal separator. This software will not work with a comma as the decimal separator. You might also need to change the display format to 1234567 instead of 1,234,567.

Converting projects from V2 to V3

All users should download the new version (SPATSIM_V3) and then convert and move their old version projects. A facility to perform this conversion is available in the SPATSIM_V3\bin folder called **`convert_to sql.exe**'.

- Double click on this executable file.
- Follow the instructions by selecting an application *.ini file from the main folder of the old SPATSIM.
- Convert the database and then move it to the new SPATSIM_V3 folder (all projects are now stored in a C:\SPATSIM_V3\Applications folder.

Updates

Updates will be posted on the web site from time-to-time, it is the responsibility of the users to make sure that they have the most up-to-date version of the software. The example database installer will not be regularly updated as every individual user is likely to modify the database for their own purposes.

2 SPATSIM GENERAL

2.1 WHAT IS SPATSIM

SPATSIM is a generic data management and model application facility:

- Includes a GIS type interface for visualizing catchment spatial data (polygons – e.g. catchment boundaries, points – e.g. gauging stations or model nodes, and lines – e.g. river channels).
- Includes a relational database management system that allows efficient access to all types of data.
- Includes a range of data management (import, export, edit) facilities.
- Includes some generic data analysis and display options that are common to many different hydrological and water resources analyses.
- Includes direct links to a range of hydrological and water resources models.

2.2 SPATSIM V3

- A new version of SPATSIM was launched in November 2017 (V3)
- The main change is in the use of a SQLite database instead of a Paradox database structure: This makes installation of the software much easier as the Paradox drivers were becoming increasingly incompatible with recent versions of Windows.
- Most of the widely used models connected to SPATSIM have been converted.
- A utility ‘convert_to_sql.exe’ is available to convert and move previous applications. (For more information to convert and move existing projects, see the RDRM_SPATSIM_guide).
- Most of the user interface has remained unchanged.
- Any future developments and support from the IWR will be limited to SPATSIM_V3.

2.3 SPATSIM MAIN INTERFACE

The SPATSIM main interface is illustrated in **Figure 2.1**. The focus in Chapter 2 to Chapter 13 is on the Desktop application of the RDRM. The use of the RDRM for applications other than desktop is presented from Chapter 14 onwards.

The process of zooming and activation of labels are illustrated in **Figure 2.2**. Note that to activate labels for any feature the ‘A’ is used in the top menu. The small (decrease) and large (increase) ‘A‘ are used to change the size of the labels.

2.3.1 Features

There are standard features listed in both applications of SPATSIM as part of Version 3. The different options for managing features are listed in a dropdown menu (**Figure 2.3**). In **Figure 2.3**, a summarised explanation of each item in the dropdown menu are supplied. The desktop users need for adding or changing features are limited. A very useful feature is the link to Google Earth which will be used to determine aspects such as slope and will be demonstrated later.

2.3.2 Attributes

There are standard attributes listed in both applications of SPATSIM as part of Version 3. The different options for managing attributes are listed in a dropdown menu (**Figure 2.4**). In **Figure 2.4**, a summarised explanation of each item in the dropdown menu are supplied. The desktop users need for adding or changing attributes are limited. The most important menu item for desktop use is the ‘import or edit’ item which relates to importing hydrology to run the RDRM.

Adding of attributes:

- Attributes contain the data that are added to SPATSIM and linked to the spatial objects.
- There are several different attribute types ranging from single values, through 1D or 2D tabular data to time series data.
- The first step in a new project is to add attribute names and specify the type of attribute.
- Once the attribute names are added, they can be populated with data using the various facilities to manually add data or import data from text files.

Attribute types:
New attribute names can be added by double clicking the attribute list or by using the ***Attribute*** and then ***Add*** menu option. It is unlikely that the desktop user will need to add attributes and the detail is not supplied in this menu.

Displaying and editing attribute data:
This option can be used to view any attribute data that has been linked to an attribute and a feature. The various options for displaying and editing attribute data is supplied in **Figure 2.5**. **Figure 2.6** gives a step by step illustration of displaying time series data for a EWR site.

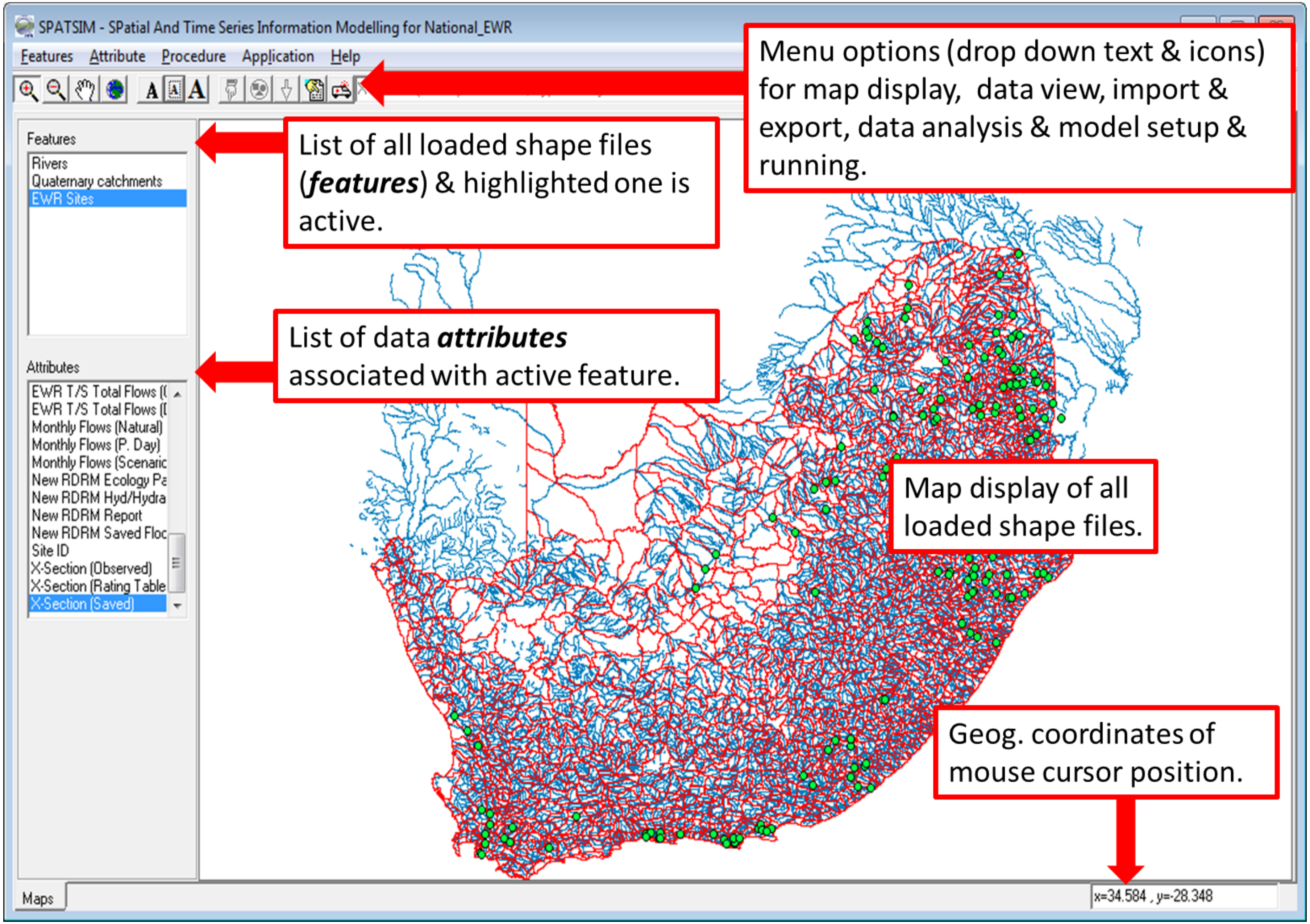


Figure 2.1 SPATSIM main interface

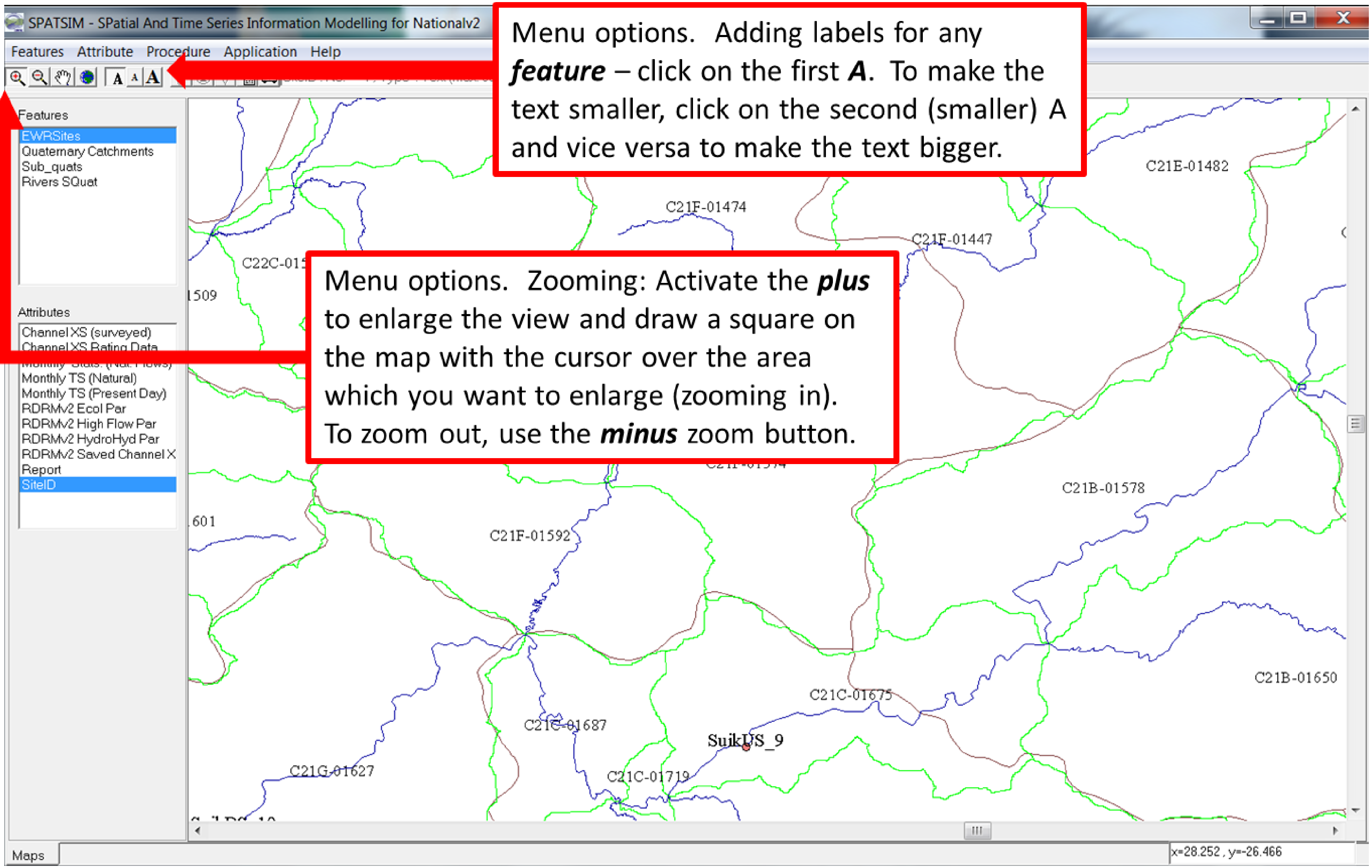
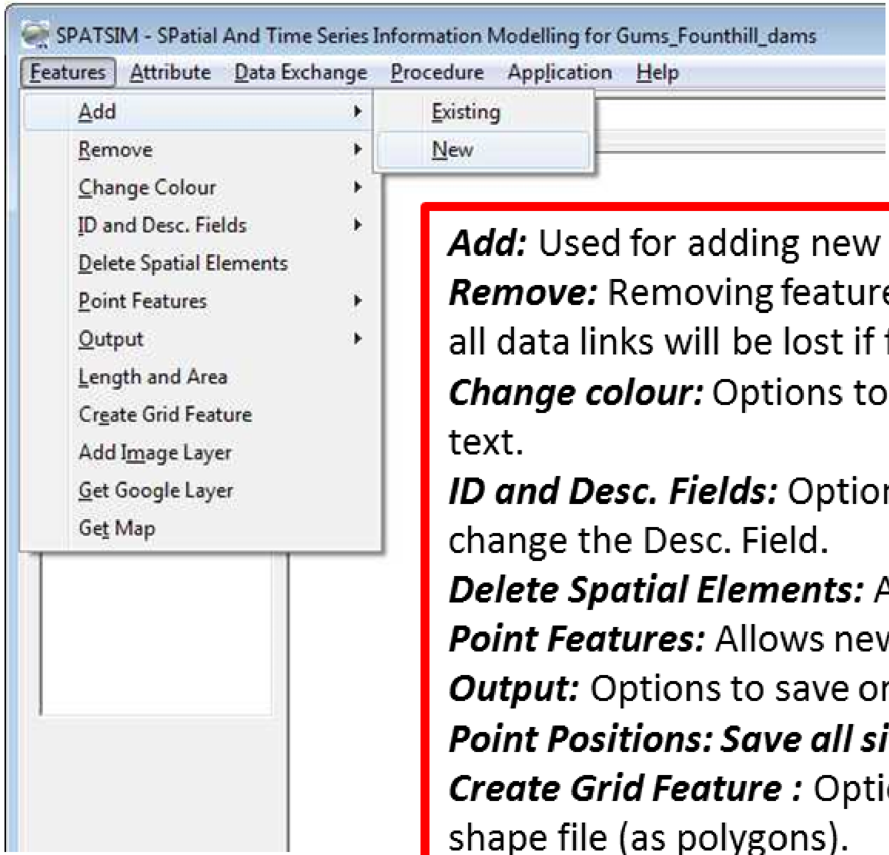
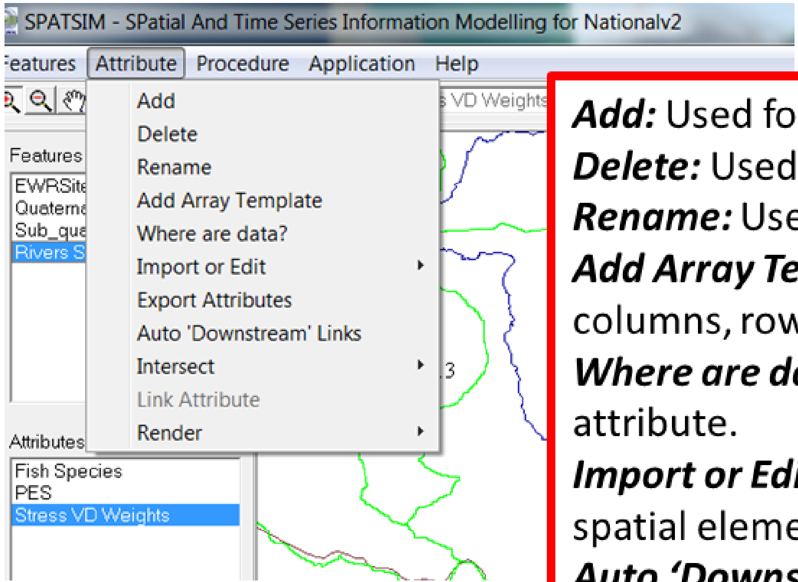


Figure 2.2 SPATSIM labels and zoom



Add: Used for adding new or existing (i.e. those already added to the database) features.
Remove: Removing features either from the view or from the database entirely (note that all data links will be lost if features are removed from the database).
Change colour: Options to change the display colour of spatial objects and description text.
ID and Desc. Fields: Options to list the data in these fields and edit the Desc. Field data or change the Desc. Field.
Delete Spatial Elements: Allows points (only) to be deleted.
Point Features: Allows new points to be added, or points moved in point type coverages.
Output: Options to save or print the displayed spatial data.
Point Positions: Save all sites as coordinates
Create Grid Feature : Option to define the extent and size of, and to create a new grid shape file (as polygons).
Add Image Layer: Option to add a geo-referenced image to the display.
Get Google Layer: Option to link to Google Earth with a kml of the displayed area and return the Google image as an image layer.
Get Map: Option to allow a digitized 1:50 000 topographic may image to be created as an image layer.

Figure 2.3 Managing features



Add: Used for adding new attributes (can also double click the attribute list).
Delete: Used for deleting attributes & the associated data.
Rename: Used for changing the name of an attribute.
Add Array Template: Used for setting up the format (numbers of rows & columns, row and column titles) of a new array type attribute.
Where are data?: Used to identify spatial elements that have data for a specific attribute.
Import or Edit: Several options for bulk importing of attribute data for many spatial elements.
Auto 'Downstream' Links: Not currently used.
Intersects: Not currently used (but designed for creating new attribute data on the basis of intersection features).
Link Attribute: Not used anymore.
Render: Used for selecting a single value attribute (or single cell of an array attribute) and using these data to colour the polygons in a feature.

Figure 2.4 Managing Attributes

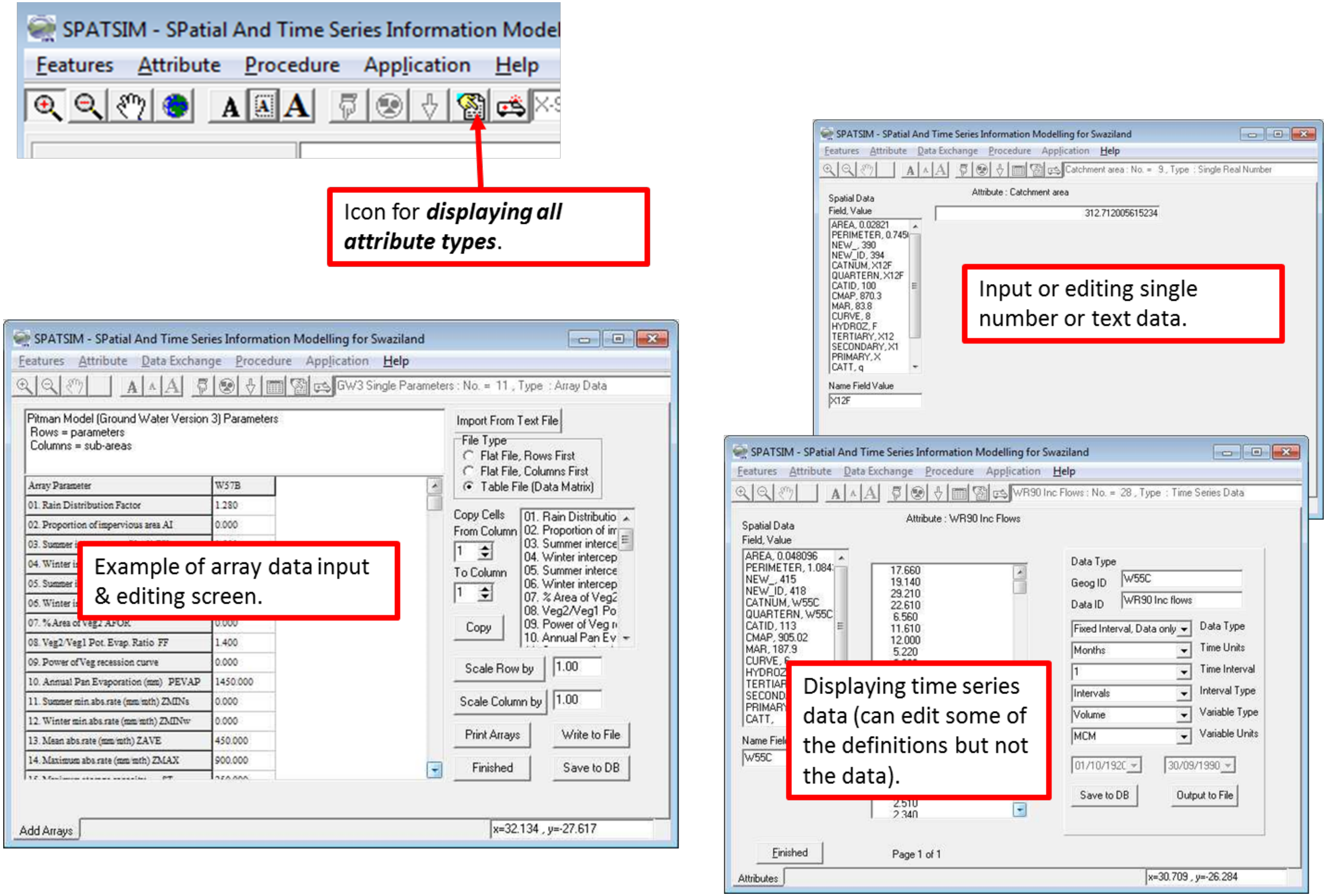


Figure 2.5 Displaying and editing attribute data (note the blocks are information blocks – not a sequence of actions)

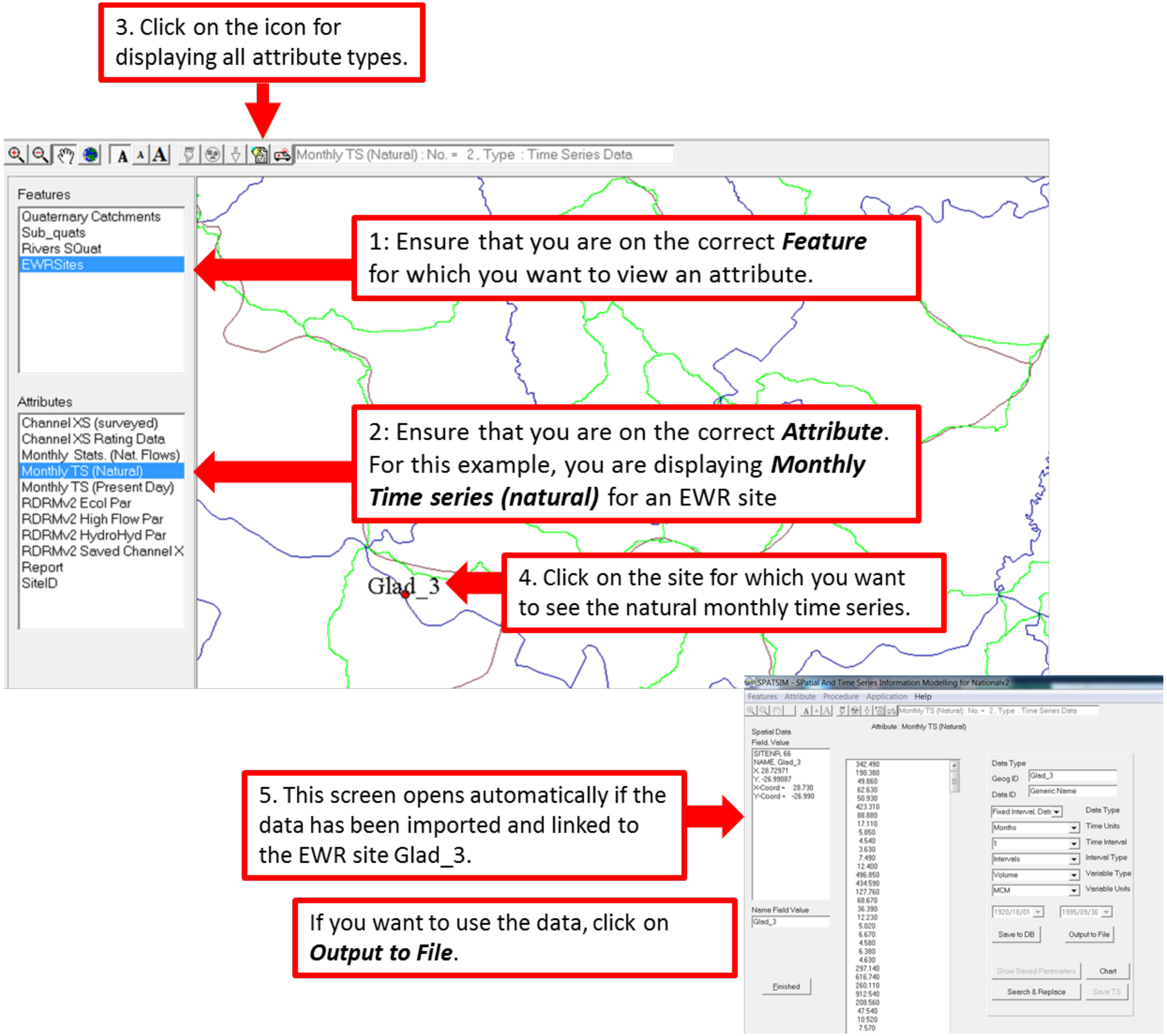


Figure 2.6 Process to view and save time series data for a EWR site

3 CREATING A POINT (EWR SITE)

EWR estimates are set for EWR sites. These may be 'real' sites, i.e. groundtruthed and selected due to specific habitat and other criteria, or it may be a node representing a river reach or catchment. In terms of desktop uses, these nodes are often a 'hypothetical' site selected at the end of a river reach.

If the site is a groundtruthed site, you will need to position it in Google Earth (for example) and then visually translate it to SPATSIM. If the site is a node at the end of a reach, it can be directly selected in SPATSIM. Note that the exact location of the site is not important as SPATSIM and the RDRM does not use the locality for any calculations.

Remember to use the feature 'Get Google Layer' to check the position of the site.

The steps in creating a EWR site in SPATSIM are illustrated in **Figure 3.1** and listed below:

- 1. The ***Feature EWR site*** must be highlighted.
- 2. Open the ***Feature menu*** item and select ***'Point Feature'***.
- 3. Select '***Add Point'*** in the sub menu
- 4. Fill in the name of the EWR site in the appropriate block. Note that any data to be used for this site must have the exact same name.
- 5. Once you have added the name, the '***pointy finger***' will be activated. Then select the position on the river where you want to locate the site. Note that if you have put the site in the wrong place move the site using the ***Feature*** to '***Move Point'***.

You can also remove a point if required following the process described in **Figure 3.2**.

Setting the Site ID Field:

- ***Features*** on ***EWRSites***
- ***Attribute*** on ***Site ID***
- Select the menu icon ***Show Attribute Data***
- Click on the site to open details
- Add the site name under the ***Attribute*** in the ***SiteID*** block which has the word ***None*** in. Make the name the same as the EWR site name, i.e. the name under the ***Name Field Value***. Click ***Finished.***

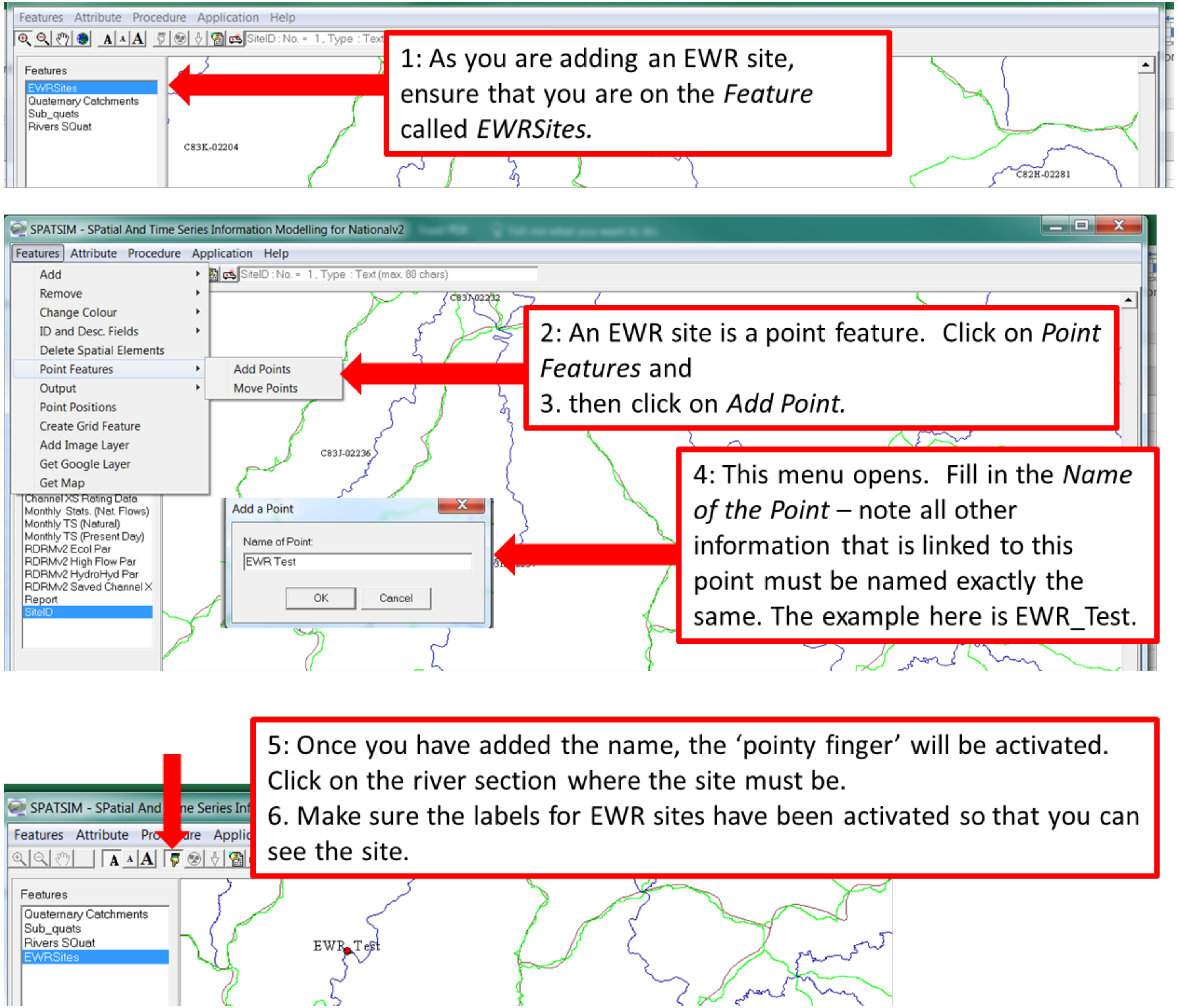


Figure 3.1 Steps required for creating a point feature (EWR site)

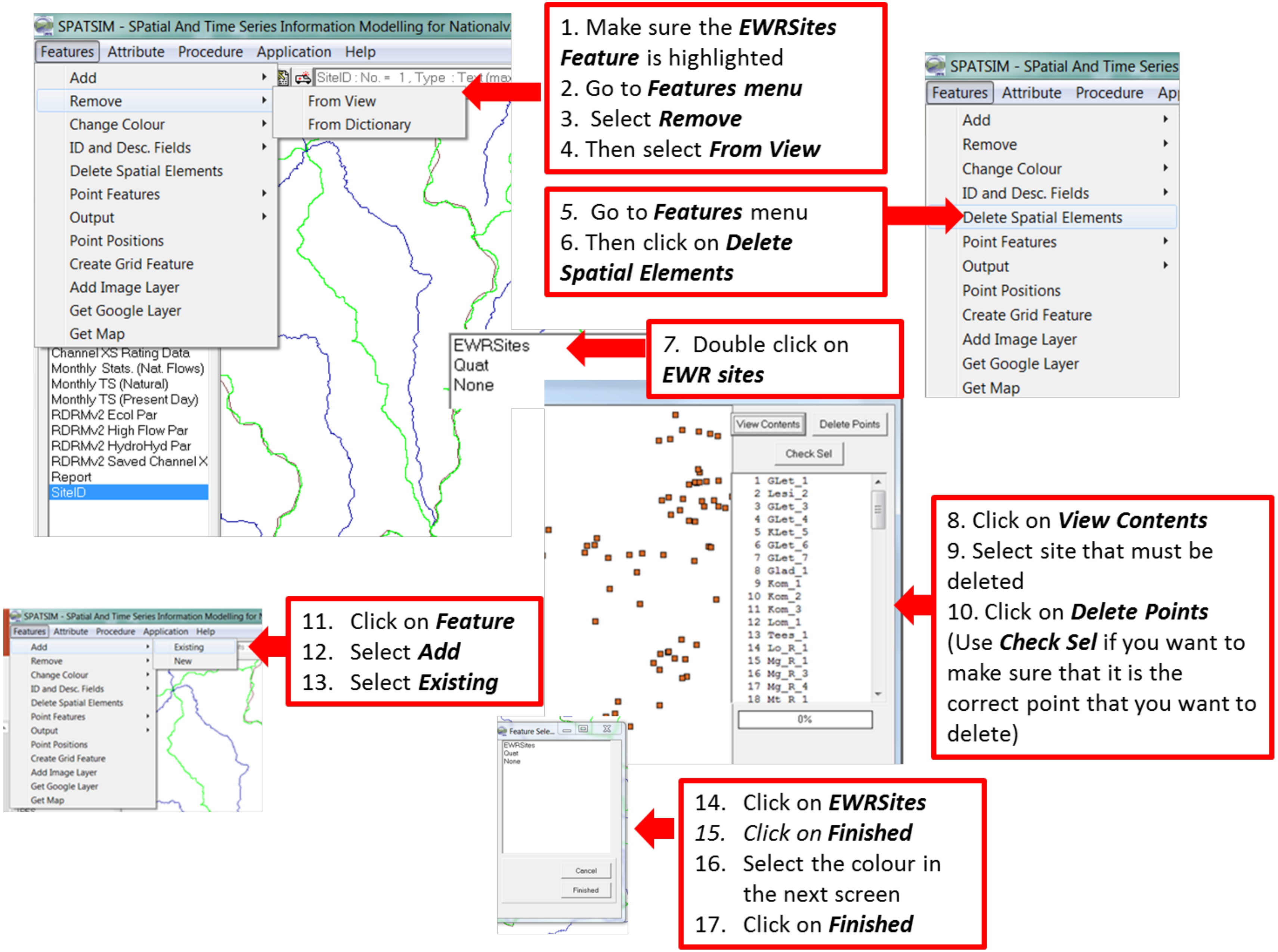


Figure 3.2 Process to remove a point (EWR site)

4 LINKING HYDROLOGY TO THE SITE

For use in the RDRM, hydrology in the form of a time series must be available. As a minimum this would be natural data in a monthly format in MCM. Ideally, present day data should also be available. The format of the hydrology must be a text file as follows:

```
EWR3,SB3 Natural Flows,10/1/1920,9/30/2005,0.00000,0.00000,0.00000,1.00000,-9.90000,0,3,1,2,0,3,2,4,1,1020
0 : 1 : 3 : 0 : 4 : 2
Start month is Oct (10)
 1920    29.000    38.540    40.330    35.100    50.090   192.010   133.580    36.750    28.240    21.720    16.750    13.660
 1921    18.250    84.760    72.930    32.330    22.850    30.580    28.020    19.330    16.410    14.210    12.370    10.610
 1922    12.020    28.980    30.760   125.260   358.490   222.430    51.520    31.290    22.290    16.950    13.420    10.600
 1923     8.270     9.710    34.320    30.460    18.500    68.580    53.620    23.090    19.120    15.270    13.420    12.660
 1924    12.930    48.750    62.750    96.010   156.180   611.980   368.760    43.610    32.950    25.890    20.230    19.370
 1925    19.050    21.310    20.240    25.280    34.250    41.870    32.750    20.470    15.630    16.750    16.610    14.020
 1926    11.600    12.870    17.610    27.980    45.000    47.750    36.400    26.900    20.670    28.060    27.590    19.770
 1927    22.640    23.920    21.690    86.190    74.330    40.970    38.390    29.960    22.510    18.210    16.310    13.730
 1928    11.780    12.490    24.300    40.260    60.670    79.930    56.060    29.900    22.590    18.860    16.120    14.750
 1929    29.800    63.230    61.470    64.840    57.860    93.420    80.060    41.430    29.090    22.510    17.890    14.110
 1930    10.750    10.390    56.860    54.340    29.080    32.960    31.590    23.230    17.800    18.210    17.330    13.810
 1931    11.660    30.590    40.520    35.290    30.400    28.410    24.540    20.060    16.730    13.570    10.990     9.020
 1932     8.500    16.610    39.470    61.260    50.310    34.410    29.770    23.800    17.750    14.350    12.350    10.520
 1933     9.880    48.850    56.060   101.290    90.510    56.090    45.450    33.450    26.090    21.470    17.480    14.720
 1934    14.210    42.260    69.610    70.180    53.550    38.840    29.080    22.330    17.730    15.450    13.450    11.320
 1935     9.940     9.370    12.860    29.410    50.190    78.690    59.450    33.520    26.570    21.710    17.930    19.260
 1936    25.300    35.950    61.870   149.670   292.470   177.950    52.770    34.510    24.690    18.630    15.090    12.910
```

The file must be named exactly the same as the EWR site name. For example, hydrology for EWR site Glad_3 must be named Glad_3.txt or Glad_3.nat. The data must be stored as a text file on your computer in a known location. Hydrology for all the EWR sites which are part of the National_EWR application is stored under SPATSIM_V3, Applications, National_EWR, data, IFR_sites_Monthly_Flows (updated) for natural flows and IFR_Sites_Monthly_Flows_(P.Day) for present day flows.

The latest official hydrology data must be used to estimate EWRs. This data can be obtained from the hydrologist involved in the most recent hydrological analysis of the study area in question. As a last resort, hydrology from WR90 can be used and it has been supplied as part of the SPATSIM database. The process is described in **Figure 4.1**. The reason no updated versions from WR90 can be problematic is because the more recent versions do not supply cumulative data amongst other.

Using WR90 hydrology for licence applications can be challenging. WR90 hydrology is provided per quaternary catchment. If your river of interest is therefore a tributary within the quaternary catchment and or the quaternary catchment represents two main rivers, you would need to do a proportional process to determine the proportion of MAR and hydrology relevant for this. Also, if your node is situated in the middle of the quaternary catchment and not at the end, you would also need to calculate the proportion of the hydrology that represents this point. It is strongly recommended that a hydrologist do these calculations and provide the hydrology.

Figure 4.2 and 4.3 illustrates the step by step process to import the hydrology which is in the correct format and named correctly, i.e. according to the site name. The process can be summarised as follows:

- Process for importing time series data using menu item ‘***Attribute***’ – ‘***Import or Edit***’ – ‘***Import T/S***’.
- The first step is to select the text files containing the data and typically this is done by naming the files using the ‘Desc.’ field contents for each spatial element (i.e. X14H.txt).

- The next step (2) is to specify the file format (various options are available) and file structure (time step, header lines, etc.). Common file types are '***spreadsheet***' (as shown) and ***continuous text*** (1 data value per line preceded by the start date).
- The last step (3) is to specify the details of the time series (e.g. units and other information – see SPATSIM Help for further details). A summary of the import results is given in the window to the left after the import is completed.

The following is important to consider:

- The file names of the time series data should correspond to the 'Desc.' field contents of the associated spatial element.
- The format of all the files to be imported should be the same.
- The expected format is displayed (top right) so that the user can check for compatibility (spreadsheet and continuous text are the most common file formats).
- The data types and units need to be carefully specified to ensure that the data are saved with the correct specifications.
- The process is repeated if present day data is available. Remember to change the attribute to ***Monthly TS (Present Day)*** when incorporating present day data.

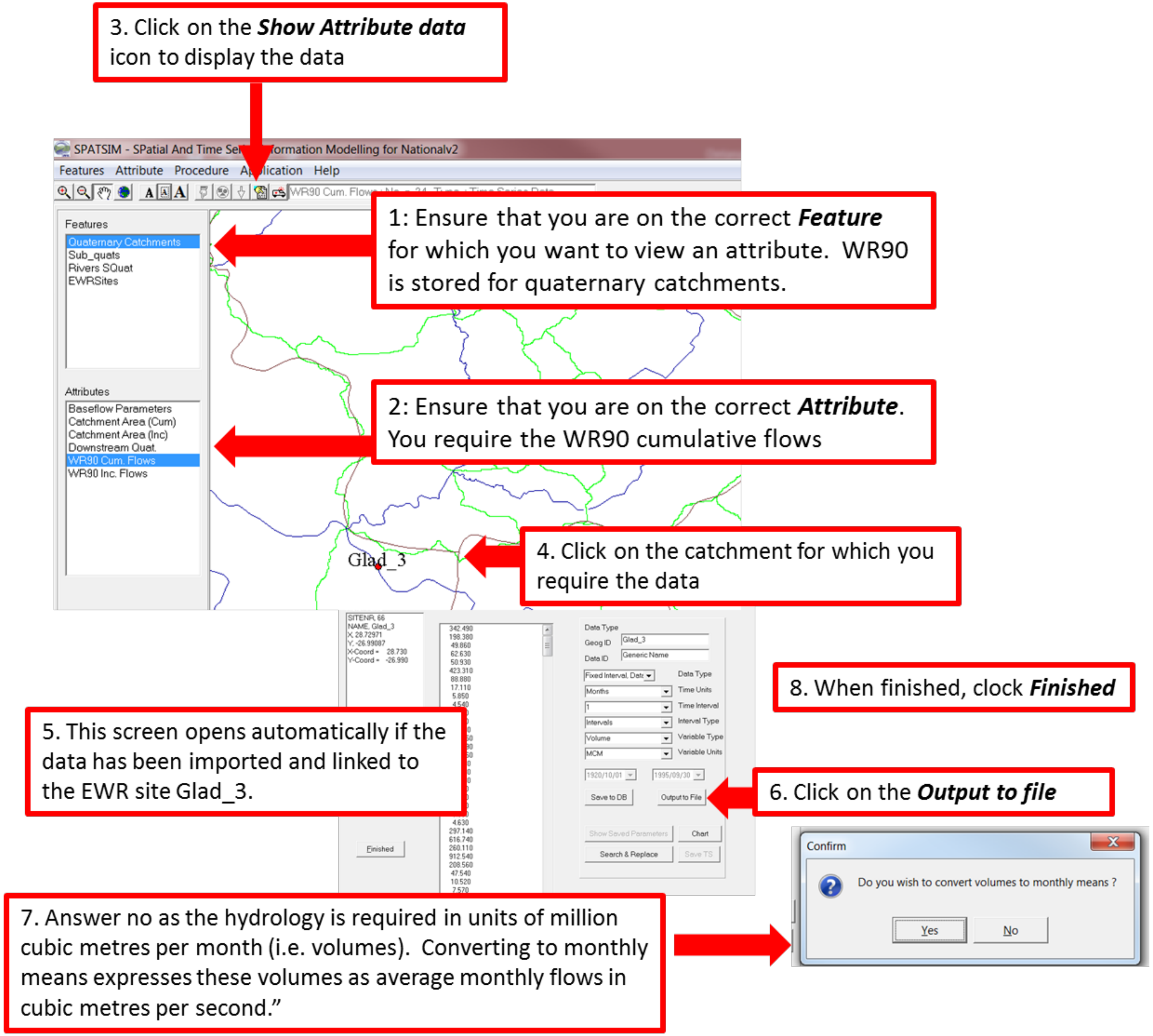


Figure 4.1 Process to extract hydrology from WR90

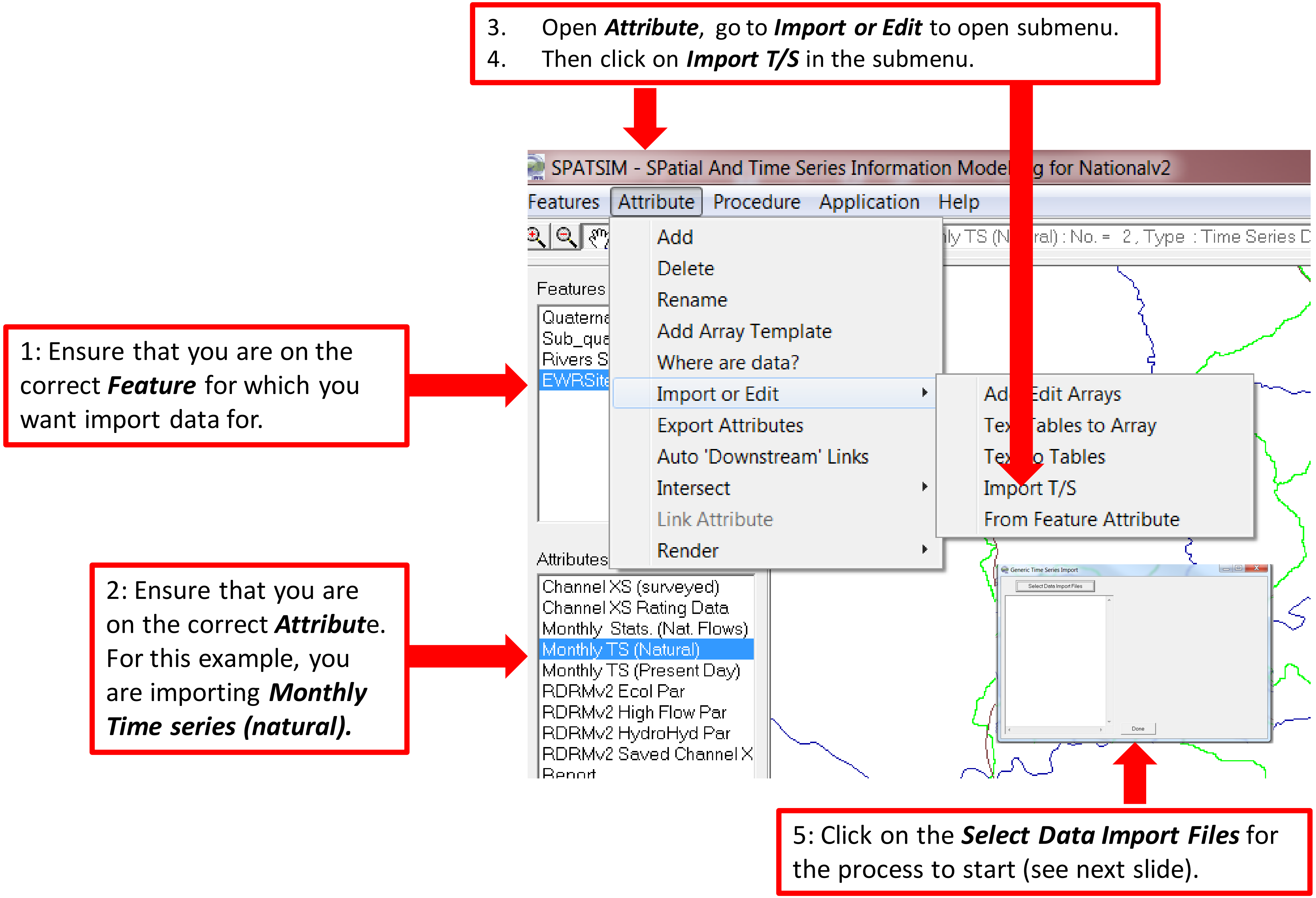


Figure 4.2 1: Importing hydrological time series

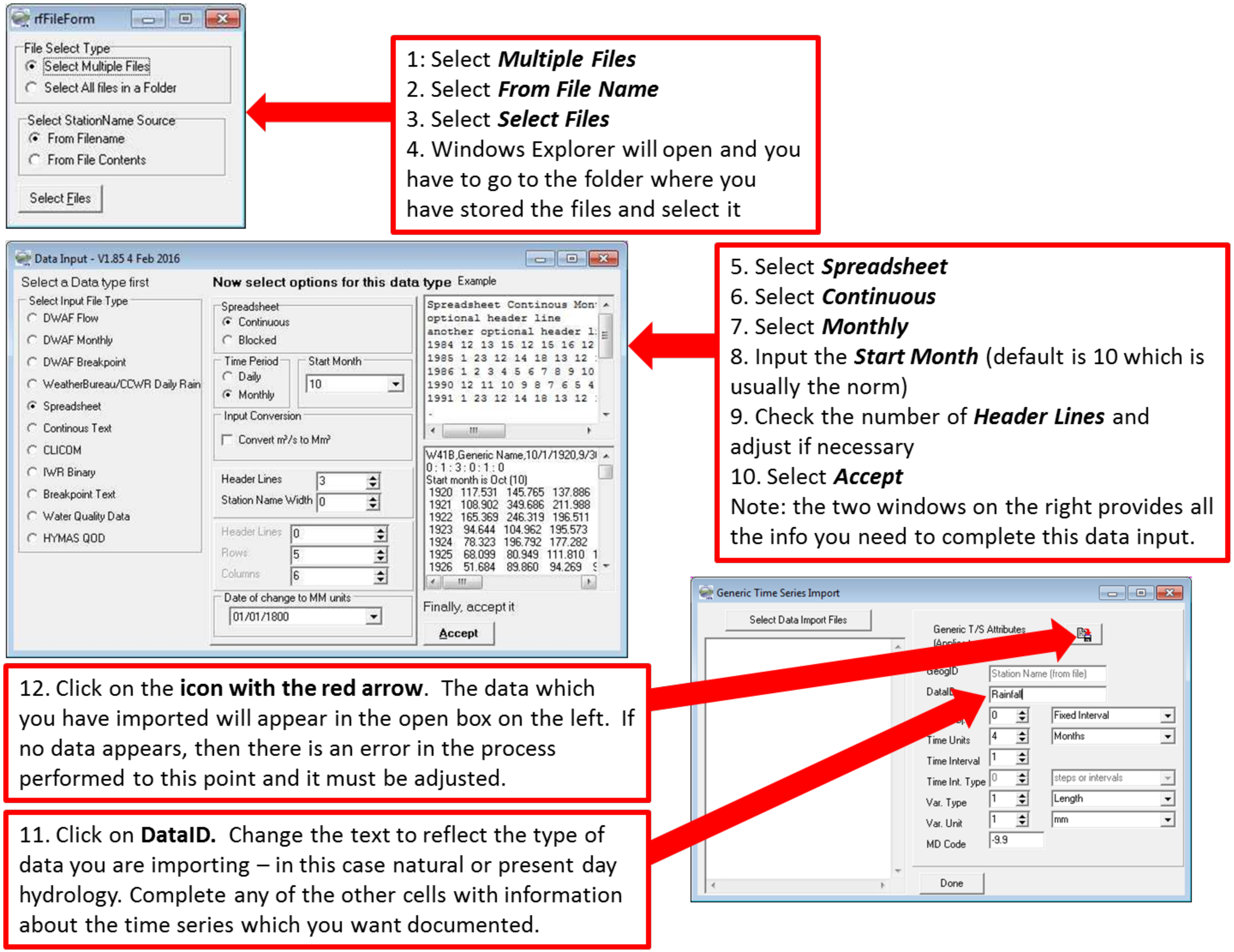


Figure 4.3 2: Importing hydrological time series

5 RDRM INPUT AND PARAMETER SETS

The RDRM input and parameter sets are provided below in red. Explanations are provided in black.

4. Site ID: Text type attribute used for the name of the site.
5. Hydrology/hydraulic parameters: Array type attribute {of type '***RDRM Hydrology and Hydraulic Parameters (Revised Desktop EWR model)***'} for the hydrology & hydraulic parameters.
6. Ecological Parameters: Array type attribute {of type '***RDRM Ecological Parameters (Revised Desktop EWR model)***'} for the ecological parameters.
7. Saved Flood Parameters: Array type attribute {of type 'RDRM Saved Flood Parameters'} which is used to save the flood category settings established through specialist input (not Desktop).
8. Saved channel X-section: Array type attribute {of type '***Hydraulic X-Section Survey Data***'} for a saved channel cross-section.
9. Surveyed channel X-section: Array type attribute {of type '***Hydraulic X-Section Survey Data***'} for a surveyed channel cross-section.
10. Stage-Discharge parameters: Array type attribute {of type '***Hydraulic X-Section Rating Curve data***'} for a table of observed rating curve parameters for a surveyed channel cross-section.
11. Natural Flow Data (T/S): Time series attribute for natural flow data.
12. Present Day Flow Data (T/S): Time series attribute for present day flow data.
13. Scenario Flow Data (T/S): Time series attribute for a scenario of flow data.
14. Total Flow Assurance Data: Array type attribute {of type '***Flow Duration Curve Tables (Frequency Distributions)***'} for storing the assurance data for total EWR requirements.
15. Low Flow Assurance Data: Array type attribute {of type '***Flow Duration Curve Tables (Frequency Distributions)***'} for storing the assurance data for low flow EWR requirements.
16. Total EWR (T/S): Time series attribute for a storing total flows EWR data.
17. Lo Flow EWR (T/S): Time series attribute for a storing low flow EWR data.
18. Report memo: Memo type attribute for storing the report.

There are two main parameter set inputs to the model, which are summarized below:

- The hydrology/hydraulic parameters.
- The ecology parameters.

Many of these parameter values are automatically estimated when the model is run for the first time on a specific site. Others can be set and/or edited during the model run. Others need to be set (within SPATSIM) before the model runs. Some of these parameters will be estimated through links to the national ecological databases.

As some of the values must be preset in SPATSIM, the parameter sets must be accessed and completed. These two parameter sets are accessed as follows:

- ***Features: EWR sites***
- ***Attributes: RDRMv2 Ecol Par*** (or ***RDRMv2 HydroHyd Par***)
- Activate the ***show attribute data***.
- Click on the site.
- Click on the right bottom block with the words ***Add/Edit Arrays***.

The array then opens and each one will be discussed further with specific emphasis on the values that must be preset.

NB: Once populated, remember to SAVE TO DB (database). (Figure 5.7)

5.1 HYDROLOGY AND HYDRAULIC PARAMETERS

The array table that must be edited is provided below. The rows in green are those rows that must be preset. Guidance on the data required to complete the table is provided in the Explanation column and in the figures below.

Table 5.1 Hydrology and hydraulic parameters (values given in the Table are only examples)

Parameter	Sample Value	Explanation
Baseflow separation (Alpha)	0.93	Two parameters of the baseflow separation equation. These are typically based on regional values or can be calibrated using the baseflow utility within TSOFT. These must be preset. (Figure 5.1)
Baseflow separation (Beta)	0.46	
Geom. Zone (1-6)	5	Geomorphic zone, from upland (1) to lowland (6) rivers. Must be preset. http://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx. See table on next page
Width/Depth Scaling	0.5	Scaling parameter c in the width – depth hydraulic geometry equation. The default value is 0.5, but it can be changed by ±0.1 if the estimated depth is too high or low.
Hydro. Variability	1.01	Does not need to be pre-set and will be calculated by the hydrology sub-model.
Valley slope (fraction)	0.003	Can be estimated from Google Earth and should be compatible with Geom. Zone. This should be preset.
Catchment Area (km^2)	1560	Used in the flood calculations and hydraulic sub-model. If not set, it defaults to 200 km^2.
Maximum Width (m)	40	Can be estimated from Google Earth. Should be preset, but will default to 40 m.
Maximum Depth (m)	2.18	Currently calculated using hydraulic geometry relationships.
Bed width (Fraction)	0.6	These parameters are all calculated from the Geomorph Zone and do not need to be preset.
Macro Roughness (m)	0.366	
Micro Roughness (m)	0.006	
Max. Gradient (fraction)	0.006	
Min. Gradient (fraction)	0.003	
Gradient variability factor	9	
Max. Manning n	0.068	
Min. Manning n	0.043	
Manning n variability factor	50	
Obs Max. Gradient	0.003	These are only used when an observed channel cross-section is used. If an observed stage-discharge rating curve is available these values should be calibrated to match the observed curve in the hydraulic sub-model.
Obs Min. Gradient	0.002	
Gradient variability factor	20	
Obs Max. Manning n	0.05	
Obs Min. Manning n	0.04	
Manning n variability factor	20	

5.1.1 Alpha and Beta Baseflow separation

The process to obtain these values are provided in ***Figure 5.1***.

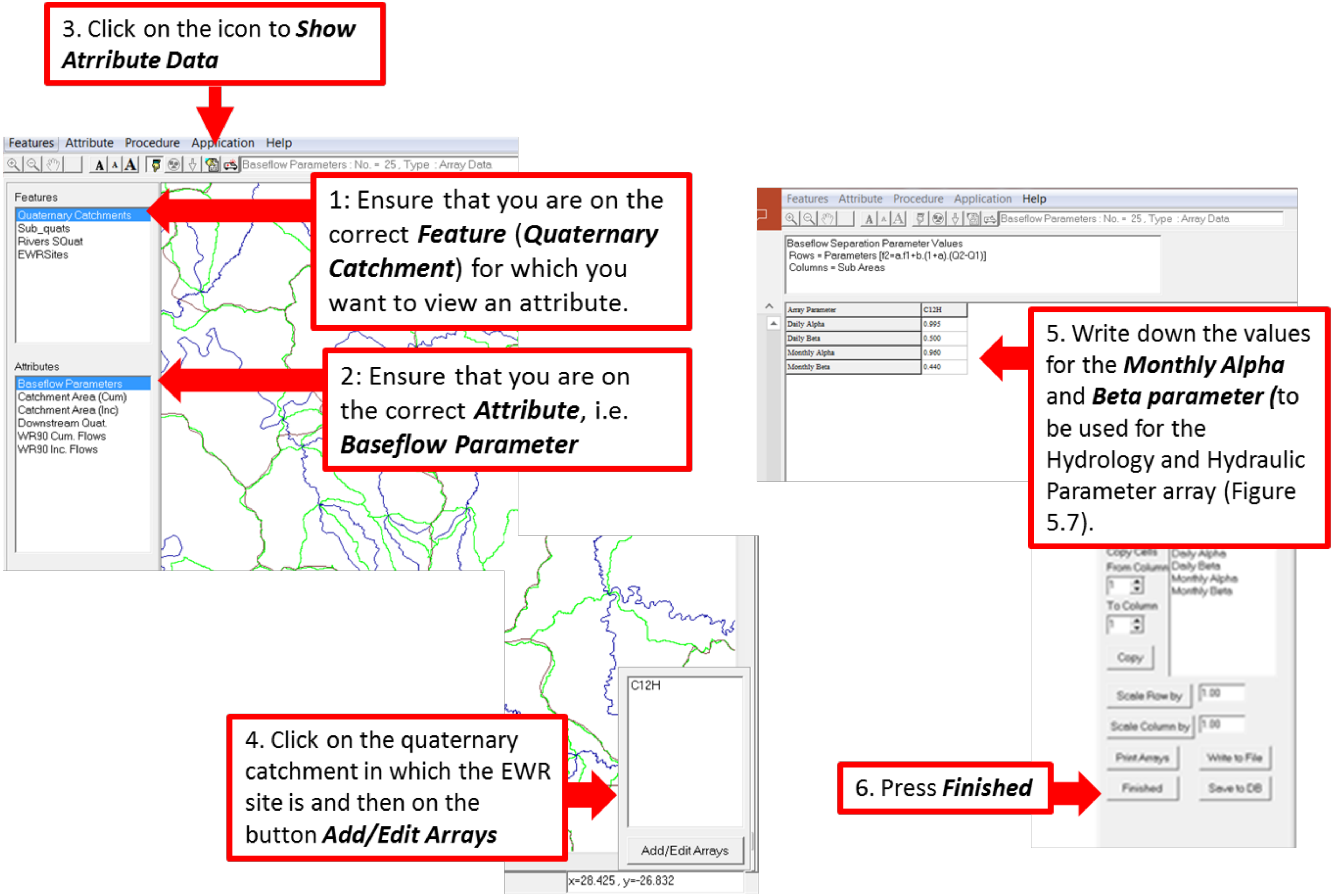


Figure 5.1 Obtaining Alpha and Beta Baseflow parameters

5.1.2 Geomorphological zone and Valley Slope

Geomorphological zones have been established for all river reaches (1:500 000 river coverage) for the sub-quaternary catchments (referred to as subquats) as part of the PESEIS study (DWS, 2014). The zones are available on the DWS website at the web address specified in ***Table 5.1***. The zones and the compatible valley slopes are provided in ***Table 5.2***.

Table 5.2 Geomorphological zones

Geomorph zones	Letter	Number	Slope
Mountain headwater stream	A	1	>0.1
Mountain stream	B	2	0.04-0.1
Transitional	C	3	0.02-0.04
Upper foothills	D	4	0.005-0.02
Lower foothills	E	5	0.0010.005
Lowland	F	6	0.0001-0.001

The existing database does however contain errors as the river coverage are incorrectly digitised in places. The valley slope must therefore also be calculated and provided. If it is not compatible with the geomorph zone, the geomorph zone must be changed to fit the valley slope.

Guidance on the process of obtaining the geomorphological zone information and calculating the slope is provided below.

- Establish in which Primary Drainage Region your river reach is.
- Download the data for the primary drainage region.
- Establish in which Secondary Drainage Region your river reach is.
- Put your site on Google Earth.
- Open the geoclass_.shp.kmz file.
- Also open the RCODE file for the secondary drainage region.
- Go to the EWR site or node, click on the river and it will give you the slope and the Geo-Class in terms of a Letter.
- Use **Table 5.1** to determine which Number corresponds to the letter and populate the table.
- Then calculate the slope to determine whether the Geomorph zone (same as Geo-Class) and slope is correct, and populate the table.

Process to calculate the valley slope from Google is provided below.

- Use the ruler and path option to determine the length of river from an area upstream to downstream of the EWR site. The exact length to use depends on the area, etc. It is suggested that you do a couple of calculations to see how sensitive the reach is. In the example that has been used (**Figure 5.2)** for EWR site BMfol_1, the reach stops quite soon after the site due to the large tributary confluence which may impact on the zone.
- Set a place mark for the upstream point and the downstream point of your river reach.
- Write down the altitude (elevation) for both points. The elevation is provided at the bottom of the Google Earth screen on the right (referred to as elev). If you do not see it, activate this option in Google Earth. Alternatively (**Figure 5.3**), once you have drawn the path, click on the Show Elevation Profile block. When you position your cursor over the starting point of the path, the elevation is provided. Move your cursor to the end of the profile to obtain the end elevation.
- Measure the length of river between these two points and calculate the slope as follows:

  Elevation US: 236 m
  Elevation DS: 233 m
  Difference in elevation: 3 m

Length of river: 2.05 km
Slope is: Difference in elevation divided by the length of river:
0.003/2.05 = 0.00146

- The database indicates that this is a Lower Foothills geomorph zone (E or number 5) with a slope of 0.003. The calculated slope is 0.00146 which also falls in the range associated with Lower Foothills.

Based on the above, the table will be populated with a geomorph zone of a 5. The valley slope will be populated using 0.002 (the measured slope on Google Earth rounded off to 0.002.

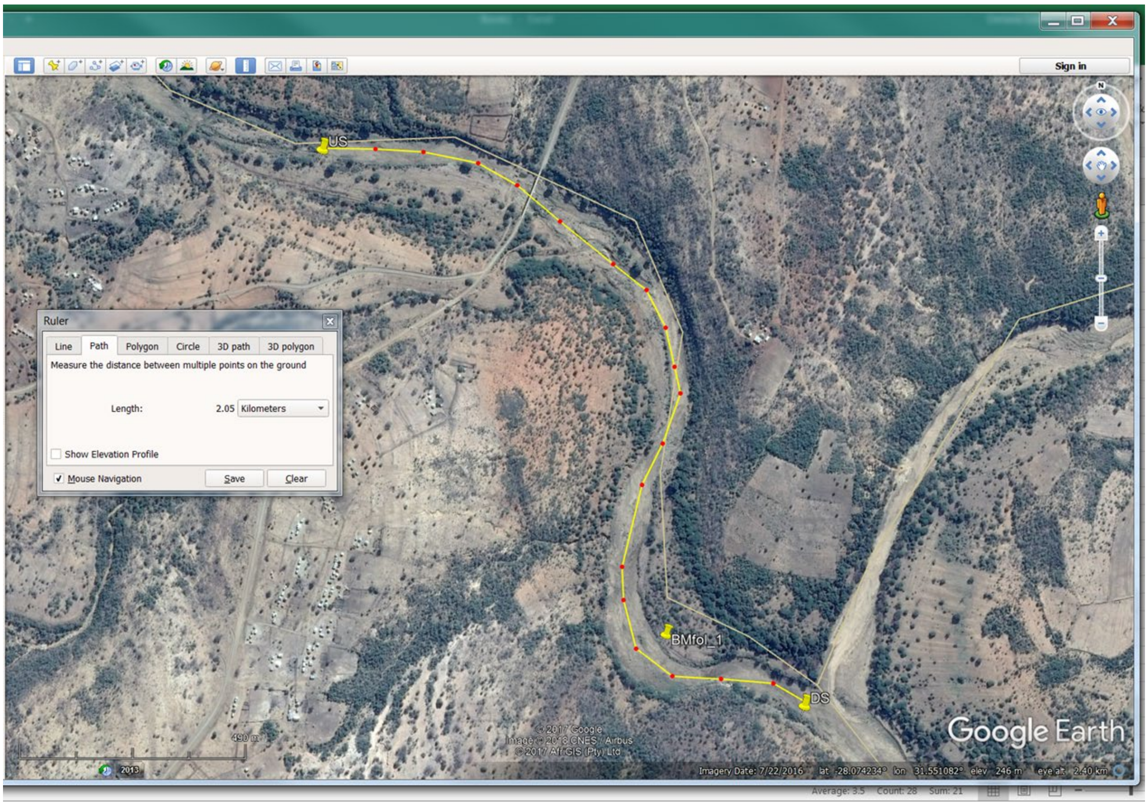


Figure 5.2 Measuring the length of river and valley slope in Google Earth

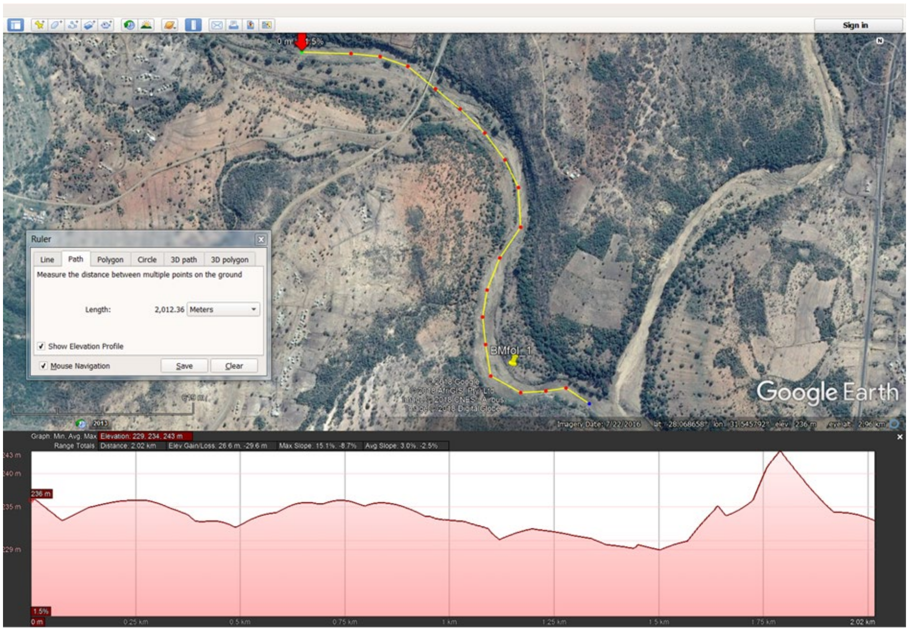


Figure 5.3 Alternative option of measuring the difference in elevation

5.1.3 Maximum Width

The maximum width is a key parameter in the desktop hydraulic assessment in the RDRM. Without measured data, the only option is to use Google Earth to measure the width (**Figure 5.4**). If the river is of variable width at the reach the site is in, the best option is to use a riffle site and measure various places or in various riffles (in close proximity of the site) and use an average.

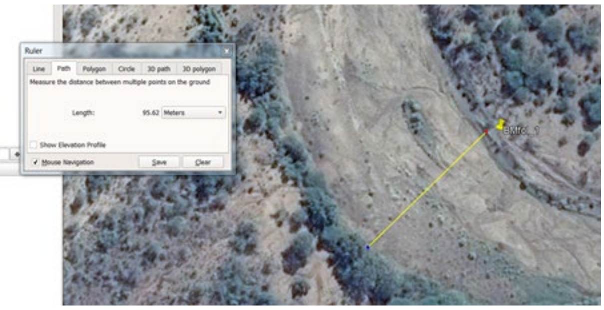


Figure 5.4 Measuring the maximum width on Google Earth

5.1.4 Catchment Area (km^2)

The catchment area is an important parameter and can be obtained from SPATSIM as illustrated in **Figure 5.5**.

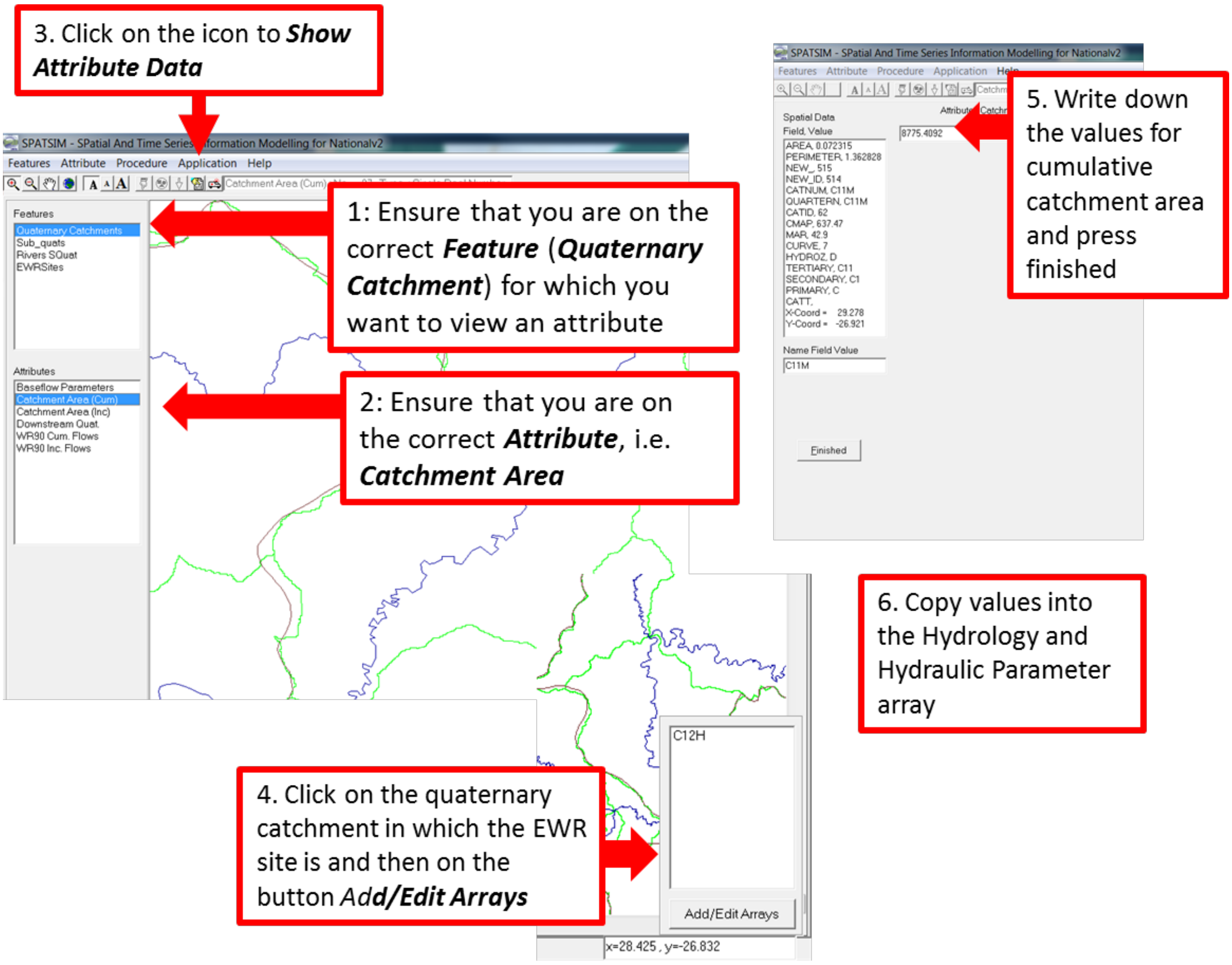


Figure 5.5 Obtaining catchment area from SPATSIM

Note however that unless your EWR site or node is in the main river at the end of a quaternary catchment, then you may need to adjust the cumulative area to represent the catchment area for the EWR site.

SPATSIM has a facility to calculate the area for a portion of a catchment and it is demonstrated in **Figure 5.6**. The example focusses on the catchment area for EWR site Thukela_12 which is situated within the quaternary catchment V20H. What one therefore must determine is the cumulative catchment area for V20G, the upstream quaternary catchment. Then ADD the portion of V20H to the area to be relevant for Thukela_12. The process to determine the quaternary catchment has been explained in Figure 5.5 and this explanation focusses on the explanation to determine the catchment area as a portion for V20H.

Note that when the result (74% – see Figure 5.6) is available, i.e. the portion of the quaternary catchment area which is relevant for Thukela_12 (or upstream of the site), one has to determine how many square kms this represents. Therefore, using the same process explained in **Figure 5.5**, the incremental catchment area for V20H must be determined. This represents that area of only this quaternary catchment. The portion (74%) of the total area for the quaternary catchment must then be calculated.

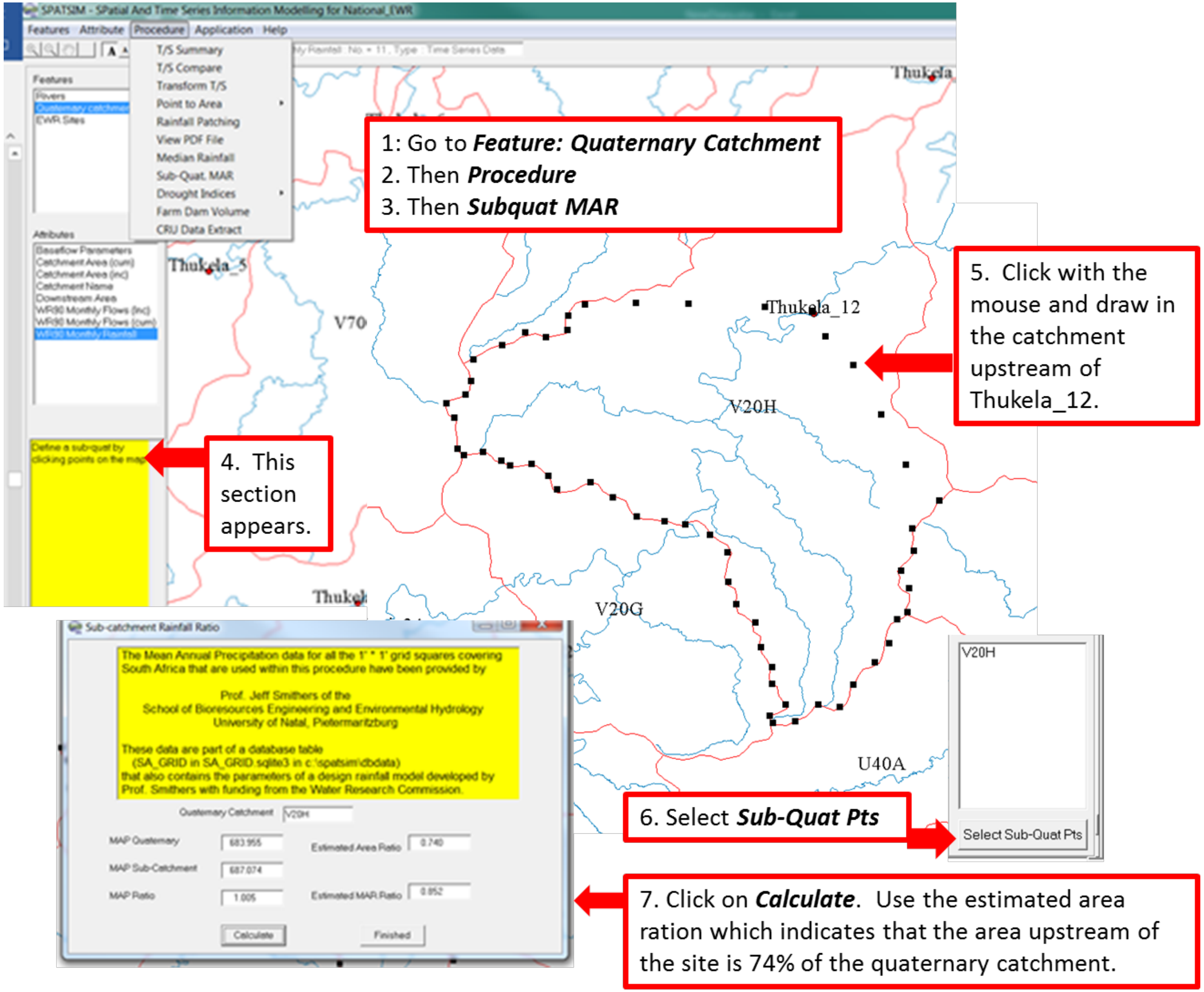


Figure 5.6 Determining catchment area for a portion of a quaternary catchment

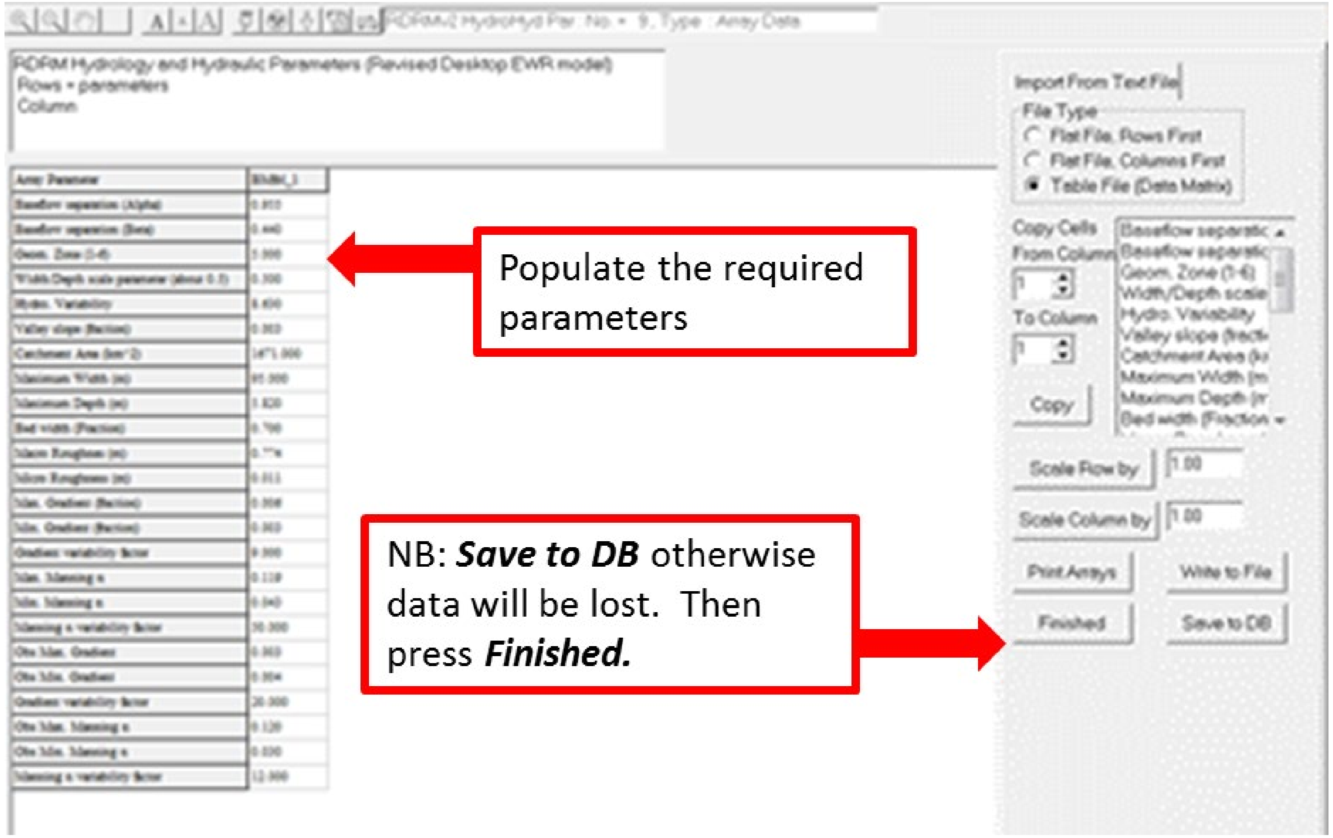


Figure 5.7 Saving hydrology and hydraulic parameters to the database

5.2 ECOLOGICAL PARAMETERS

The array table that must be edited is provided below. The rows in green are those rows that must be preset. Guidance on the data required to complete the table is provided in the Explanation column and in the figures below.

Table 5.3 Ecological parameters (values given in the Table are only examples)

Parameter	Value	Explanation
Max. baseflow FDC	20	Part of the hydrology sub-model Must be preset.
Perennial Index (0-2)	0	A parameter used to force (or not) perenniality in the Reserve flows.
Alignment Index (0-7)	0	A parameter used to align the stress frequency curves to present day conditions (rather than being based on natural flow and stress conditions)
High Shift Wet A	2	These are used to define the shapes of the stress frequency curves for the different ecological protection categories. Default values are calculated by the model, but they can be adjusted by the user, where appropriate and if there is additional information available to suggest changes.
High Shift Wet B	2.903	
High Shift Wet C	4.257	
High Shift Wet D	6.062	
High Shift Dry A	3.8	
High Shift Dry B	4.529	
High Shift Dry C	5.622	
High Shift Dry D	7.079	
Low Shift Wet A	0.4	
Low Shift Wet B	0.485	
Low Shift Wet C	0.613	
Low Shift Wet D	0.783	
Low Shift Dry A	0.3	
Low Shift Dry B	0.434	
Low Shift Dry C	0.636	
Low Shift Dry D	0.904	
Wet Stress at 0% FS	9	These define the way in which the Flow-stress relationships are estimated using the hydraulic habitat data. The weights should be based on the actual requirements of fish and invertebrates that are expected to be present in the river. These should be preset and the data can be obtained from the ***Features Rivers SQuat*** and the ***Attribute Stress VD Weights.*** **(Figure 5.8)**
Wet FS Weight	1	
Wet FI Weight	1	
Wet FD Weight	2	
Dry Stress at 0 FS	9	
Dry FS Weight	1	
Dry FI Weight	1	
Dry FD Weight	2	

5.2.1 Maximum baseflow percentile (Max. baseflow FDC)

This value must be pre-set and can be changed in the model. If it is not pre-set, the model will produce an error. Use 20% as the default value. Once you run the RDRM model and additional information requires you to change the value, it can be changed in RDRM.

5.2.2 Velocity Depth Category weights

The **ecological component** of the model relies on a relationship between flow and ecological habitat stress and it makes use of the estimations of available habitat from the hydraulics model. This component uses three velocity-depth categories, namely fast-deep (>0.3 m/s and deeper than 0.3m), fast-intermediate (>0.3 m/s and ranging between 0.2m and 0.3m in depth) and fast-shallow (>0.3 m/s and ranging in depth between 0.1m and 0.2m in depth) habitats and the flow-stress relationship is based on how the frequencies of the habitats change with changing flow (velocity-depth categories

[1]from Kleynhans 2003). The model includes parameters that are used to weight the importance of these three fast habitats depending on the presence of different fish species in the reach. Fish species differ in their requirement for different velocity-depth habitats, with rheophilic species generally having a preference for fast habitats while limnophilic species prefer slow habitats. The possibility to also consider macroinvertebrates in this weighting process was investigated as part of this WRC project. As with the fish species, macroinvertebrate taxa information is also available on a sub-quaternary reach level as part of the DWS PESEIES project information (reference?). Macroinvertebrate habitats are however generally described (as part of the reserve determination process) in terms of velocity and substrate/cover (rather than depth as in the case of fish). The revised RDRM ecological sub-model utilises velocity-depth categories in the calculation of model. An attempt was made during the study to interpret the macroinvertebrate velocity-substrate habitats in terms of velocity-depth habitats, but this will require further verification by specialists and testing in future before it can be included as part of the weighting process in the revised RDRM model. When the revised RDRM model is applied by an aquatic specialist, the macroinvertebrate assemblage of a site/reach can however be used to manually alter the weightings (refer to chapter 19 of this report for detail on specialist use). In a purely desktop application of the model, the fish species composition and hence requirement for different velocity-depth categories will be automatically used to calculate the weights. Should the model detect that there is no fish in a reach/site, it will revert to using a default "invertebrate" rating. This is based on the assumption that although there may not be fish present that requires fast habitats, there may very likely be inveterate taxa with a requirement for fast habitats and that these should therefore be consider as important. The default ratings used in the model for invertebrates (if no fish present) is as follows:

Wet Stress at 0% FS:	9
Wet FS Weight:	2
Wet FI Weight:	1
Wet FD Weight:	0
Dry Stress at 0% FS:	5
Dry FS Weight:	3
Dry FI Weight:	1
Dry FD Weight:	0

The desktop user should therefore only use the relevant weightings available in the SPATSIM database as follows (**Figure 5.8**):

[1] **Fast Very Shallow (FVS):** >0.3m/s; <0.1m; **Fast Shallow (FS):** >0.3m/s; 0.1-0.2m, **Fast Intermediate (FI):** >0.3m/s;0.2-0.3m; **Fast Deep (FD):** >0.3m/s;>0.3m; **Slow Shallow (SS):** <0.3m/s;<0.5m; **Slow Deep (SD):** <0.3m/s;>0.5m

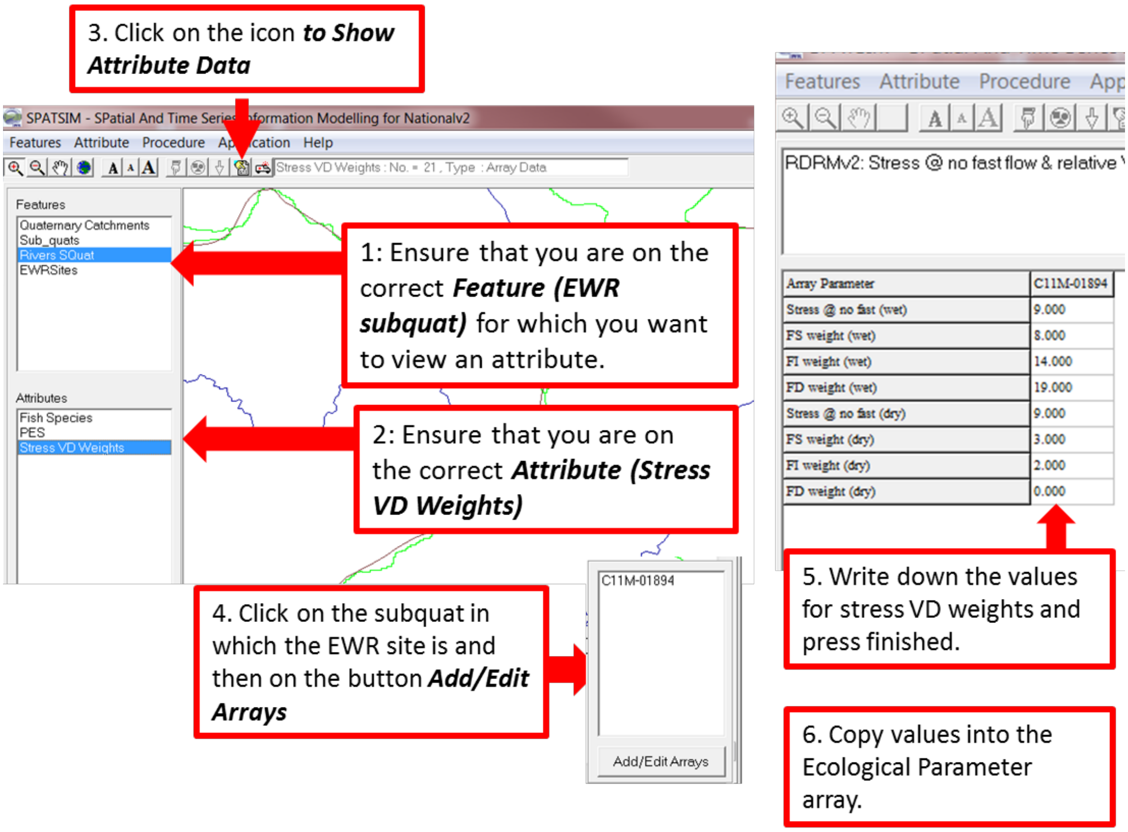


Figure 5.8 Obtaining Velocity Depth Weights according to fish species from SPATSIM

5.2.3 PES – where to obtain and interpret

The information below is on the assumption that EcoClassification information other than Desktop is not available and therefore the PESEIS data must be used. The PESEIS data is obtained in a similar fashion than above and illustrated in **Figure 5.9**.

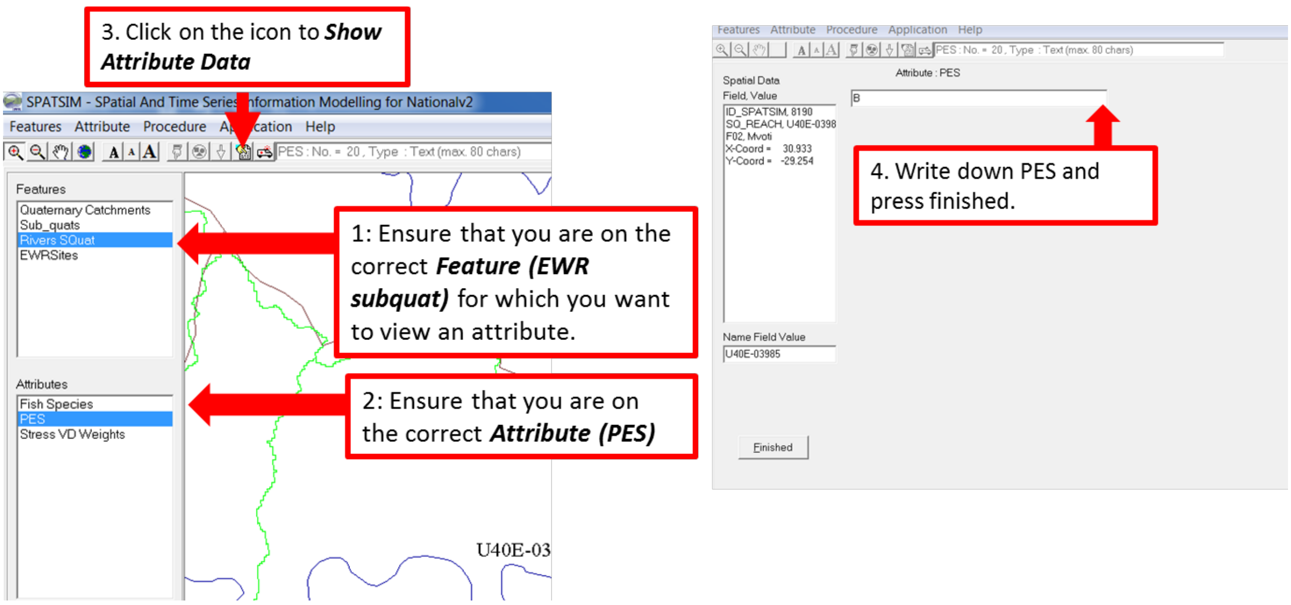


Figure 5.9 Obtaining PES information from the PESEIS database

As part of the EcoClassification process, the EWR is usually required for the REC and therefore further information should be obtained from the PESEIS spreadsheet which you have downloaded previously. Based on the guideline regarding Importance and Sensitivity, a decision must be made whether the REC is set to maintain the PES or to improve the PES.

If the REC is an improvement of the PES, a broad assumption (with the limited information available) must be made on whether the improvement is flow related or not. If the improvement is NOT flow related, the flows should not be improved beyond that required for the PES. In these cases, the model outputs for the PES will be used as the Preliminary Reserve to achieve the REC. In your rationale in reports or templates, an indication should be provided of the actions required to achieve the REC.

As an example, the following hypothetical situation is presented:

- The PES is a C, the importance is high and the REC should be a C.
- Evaluate the individual metrics for the PES. If the flow is a 1 or zero, and the riparian metrics are higher, it is likely that the improvement will be non-flow related.
- Save the results and time series for the C PES.
- Provide the EWR rule of the C Ecological Category for your site and a REC of a B. Note, the REC does not become a C. It stays a B but the B is achieved through addressing the non-flow related issues and providing the C EWR.
- NB: Document your rationale.

6 LINKING SPATSIM INFORMATION TO RDRM

The purpose of this section is to illustrate the establishment of a model application. This is a generic approach for all models and involves the following steps:

- Identify and select the spatial elements that are to be modelled (this may be a single element for such as the Revised Desktop Reserve model, or a group of linked elements for such as a rainfall-runoff model).
- Select the model type to be run. This will display the model input and output types.
- Connect the SPATSIM attributes to the list of model input and output requirements. Note that some requirements are compulsory, while others are optional.
- Save the model run to the Proc_Run table, giving it a name and checking that the start and end dates for the model run are compatible with the data inputs.

The first step is to link the RDRM model data requirement to a file or attribute stored in SPATSIM. The model data requirements are provided in red below with an explanation.

4. Site ID: Text type attribute used for the name of the site.
5. Hydrology/hydraulic parameters: Array type attribute {of type '***RDRM Hydrology and Hydraulic Parameters (Revised Desktop EWR model)***'} for the hydrology & hydraulic parameters.
6. Ecological Parameters: Array type attribute {of type '***RDRM Ecological Parameters (Revised Desktop EWR model)***'} for the ecological parameters.
7. Saved Flood Parameters: Array type attribute {of type 'RDRM Saved Flood Parameters'} which is used to save the flood category settings established through specialist input (not Desktop).
8. Saved channel X-section: Array type attribute {of type '***Hydraulic X-Section Survey Data***'} for a saved channel cross-section.
9. Surveyed channel X-section: Array type attribute {of type '***Hydraulic X-Section Survey Data***'} for a surveyed channel cross-section.
10. Stage-Discharge parameters: Array type attribute {of type '***Hydraulic X-Section Rating Curve data***'} for a table of observed rating curve parameters for a surveyed channel cross-section.
11. Natural Flow Data (T/S): Time series attribute for natural flow data.
12. Present Day Flow Data (T/S): Time series attribute for present day flow data.
13. Scenario Flow Data (T/S): Time series attribute for a scenario of flow data.
14. Total Flow Assurance Data: Array type attribute {of type '***Flow Duration Curve Tables (Frequency Distributions)***'} for storing the assurance data for total EWR requirements.
15. Low Flow Assurance Data: Array type attribute {of type '***Flow Duration Curve Tables (Frequency Distributions)***'} for storing the assurance data for low flow EWR requirements.
16. Total EWR (T/S): Time series attribute for a storing total flows EWR data.
17. Lo Flow EWR (T/S): Time series attribute for a storing low flow EWR data.
18. Report memo: Memo type attribute for storing the report.

Table 6.1 Model format files (see SPATSIM/test_data folder)

The table from the model indicating the Attributes that must be linked to the model is provided as **Table 6.2.** The process to link these files in the model is demonstrated in **Figure 6.1.**

Table 6.2 Table linking RDRM data requirements with the attributes

Model Data Requirement or Optional	Rq/Opt	File/Attribute	Comment
1. EXE File		new rdrm.exe	
2. Output Requirement File		Not Applicable	
3. Not Applicable	Opt		
4. Site ID	Req	SiteID	
5. Hydrology/hydraulic parameters	Req	RDRMv2HydroHydPar	

Model Data Requirement or Optional	Rq/Opt	File/Attribute	Comment
6. Ecological Parameters	Req	RDRMv2 Ecol Par	
7. Saved Flood Parameters	Opt	RDRMv2 High Flow par	
8. Saved channel X-section	Opt	RDRMv2 Saved Channel XS	This ensures that if you save a random generated cross-section, the same cross-section will be used if you need to run the model again.
9. Surveyed channel X-section	Opt	Channel XS (surveyed)	Only required if channel was surveyed
10. Stage-Discharge parameters	Opt	Channel XS Rating Data	Only required if channel was surveyed and modelling undertaken.
11. Natural Flow Data (T/S)	Req	Monthly TS (Natural)	
12. Present Day Flow Data (T/S)	Opt	Monthly TS (Present Day)	Only required if present day data is available
13. Scenario Flow Data (T/S)	Opt		
14. Total Flow Assurance Data	Opt	Assurance Monthly Total C	These attributes may not have been created in your Attribute list. One can add all of the categories, or systematically add the category which is relevant for your site. In this example, the REC is a C and one would want to store this data in the database. Therefore, the relevant attributes for an EC of a C was created and linked to 14, 15, 16 and 17.
15. Low Flow Assurance Data	Opt	Assurance Monthly Low C	
16. Total EWR (T/S)	Opt	Monthly Total T/S C	Important to add as this ensures that the time series is available to extract for use in any systems and yield modelling.
17. Low Flow EWR (T/S)	Opt	Monthly Low T/S C	See above.
18. Report memo	Opt	Report	Very important as this will allow the final product to be produced.

Once finished populating the table, select save requirement. Save it to a new record, give the EWR a name and click on finished. At this point, you are ready to run the RDRM. One can either exit here and run the model as outlined in the next chapter or run directly from this display.

Note that you can go back and edit a saved run (***Edit Saved Run*** under the options ***Application, Run Process***) at any stage and then save it to an existing record.

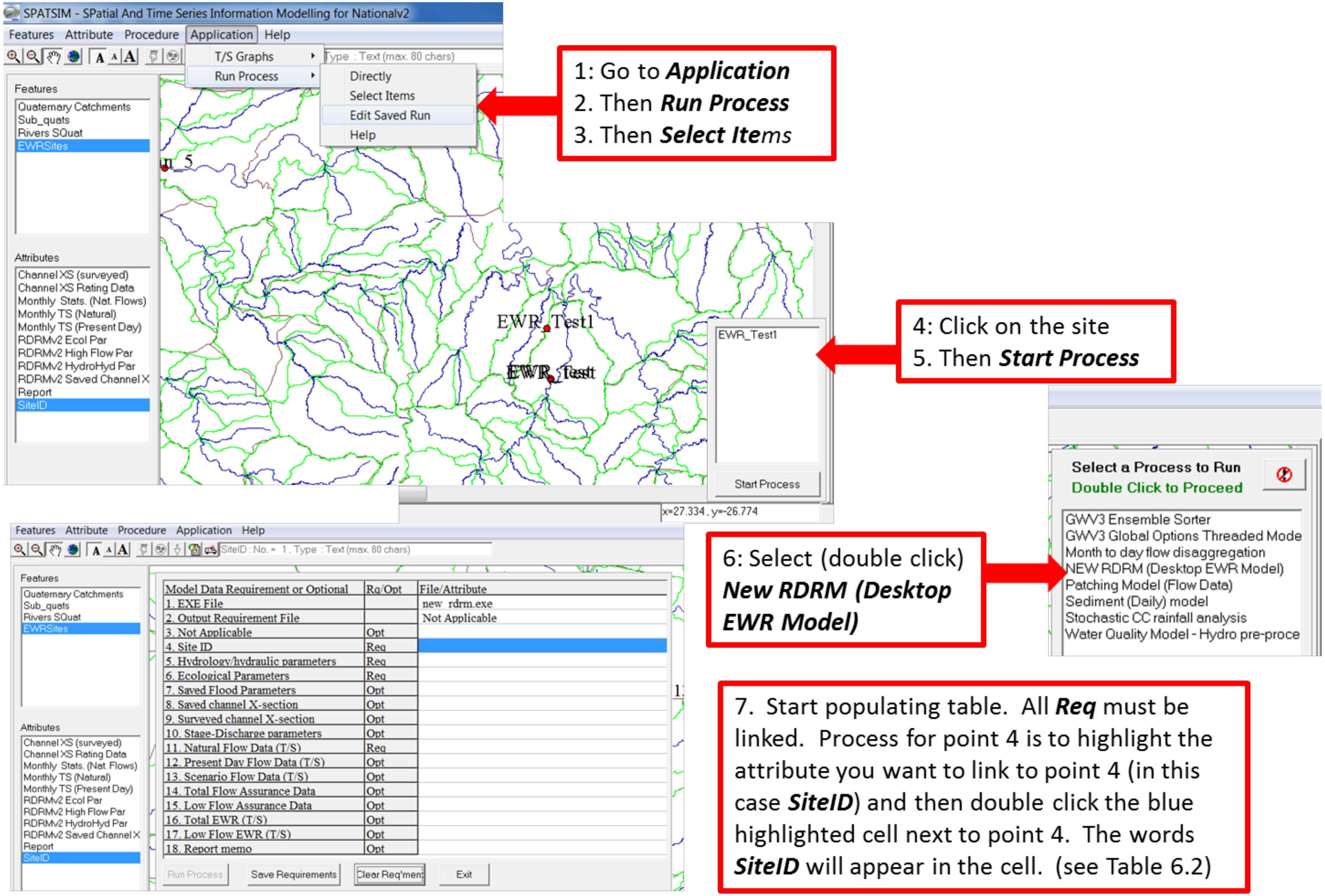


Figure 6.1 Process to get to the table to link attributes to RDRM model requirement

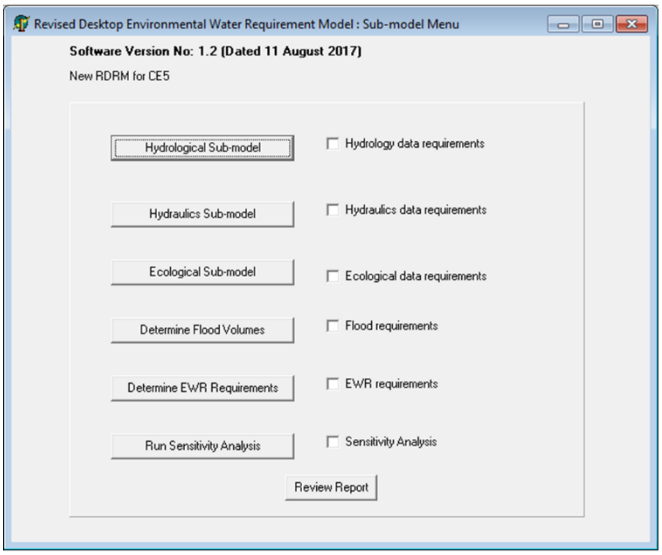
7 REVISED DESKTOP RESERVE MODEL (VERSION 2)

Once the model has been set up, it can now be run to estimate the EWR.

Go to

- ***Application***
- ***Run Process***
- ***Directly***
- ***New RDRM (Desktop EWR Model)***
- ***Select the EWR site***
- ***Read Data***
- ***Run Model***.

The main screen showing the sub-models (**Figure 7.1**) will open.



The sub-models have to be completed in order, as each one provides information for the next.

The sensitivity analysis button allows the user to explore some of the output sensitivity to changes in key input parameters or other model options.

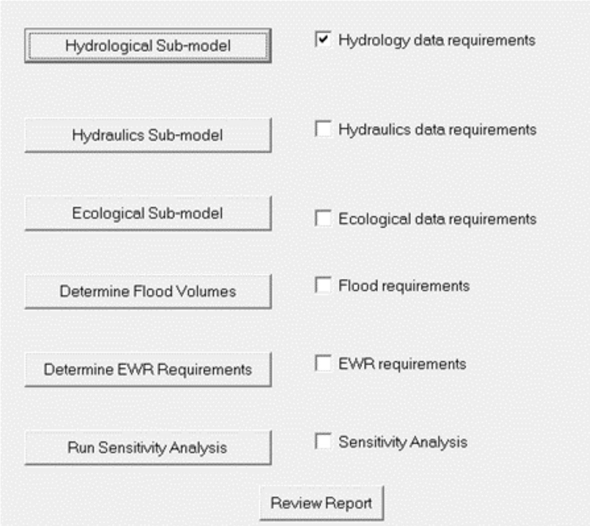
If a report (summary of all the inputs, parameters and output) is required, it must be generated in the Hydrological sub-model first.

The 'Review Report' button allows the report to be viewed in a separate window (and copied to a file if required).

Figure 7.1 RDRM Main screen

8 HYDROLOGY SUB-MODEL

Start with the Hydrology Sub-model and open the screen (**Figure 8.2**). At this point you do not need to do anything on this screen apart from checking that the hydrology data provided is the correct data for the EWR site by, for example, comparing the nMAR.



Select: ***Go to Graphics Plots***

The graphics plots screen will open (**Figure 8.1**). The only parameter is the maximum baseflow % point used to determine the wet and dry season maximum baseflow values. Typically, a value of 10% to 20% is appropriate. This parameter is designed to avoid using the absolute maximum baseflow that may be affected by artifacts of the baseflow separation algorithm.

There may be uncertainty whether 20% is the correct percentile for the maximum base flow. No rules or guidance on selecting the maximum base flow can be provided. It is recommended that if the results are unexpectedly high or low, that you run a sensitivity analysis (last option in the RDRM) and adjust the maximum base flow if necessary.

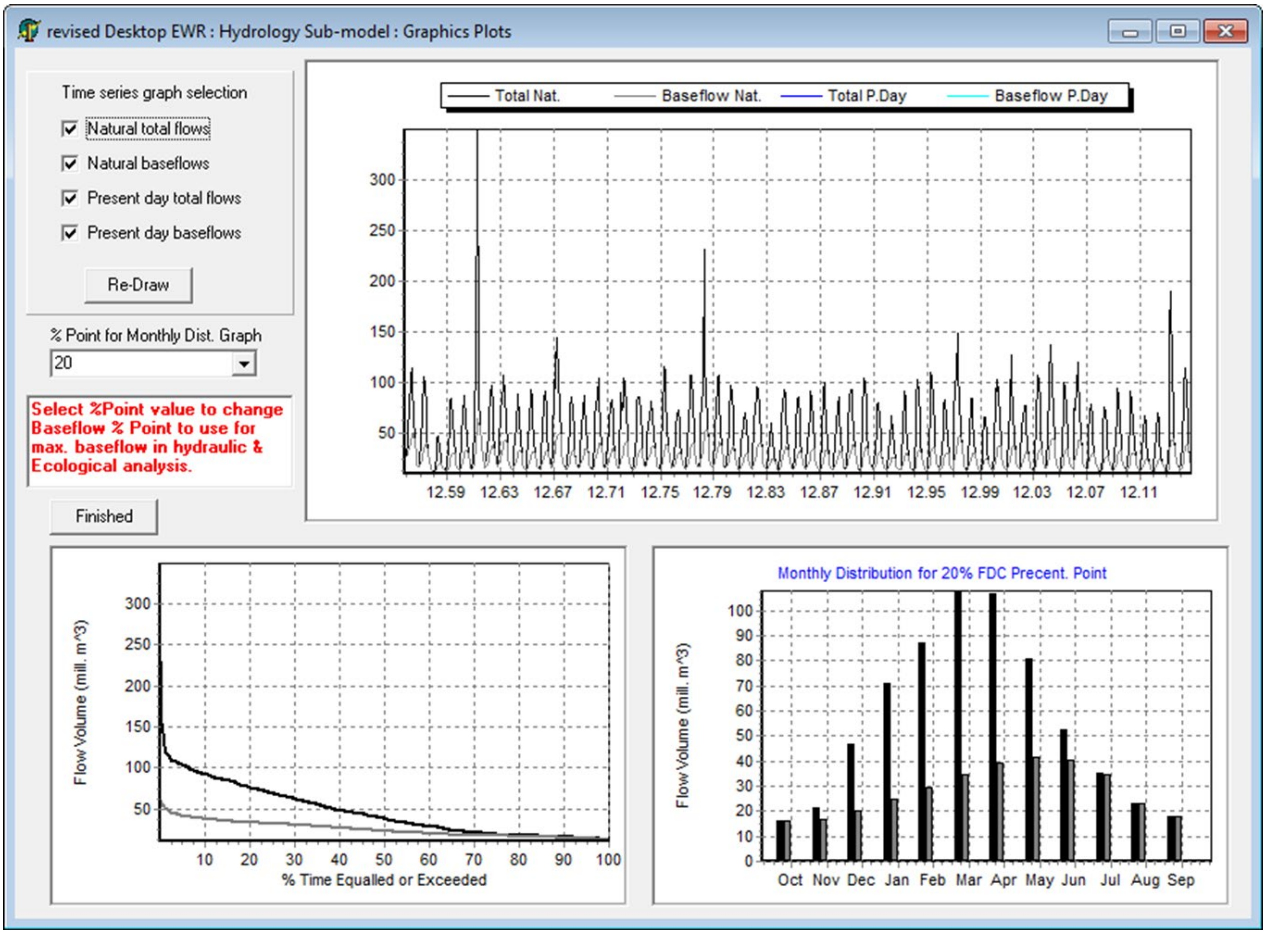


Figure 8.1 RDRM: The graphics plot screen of the hydrology sub-model

Select ***Finished*** once you have accepted or adjusted the maximum baseflow and the model will revert to the first screen of the hydrology sub-model.

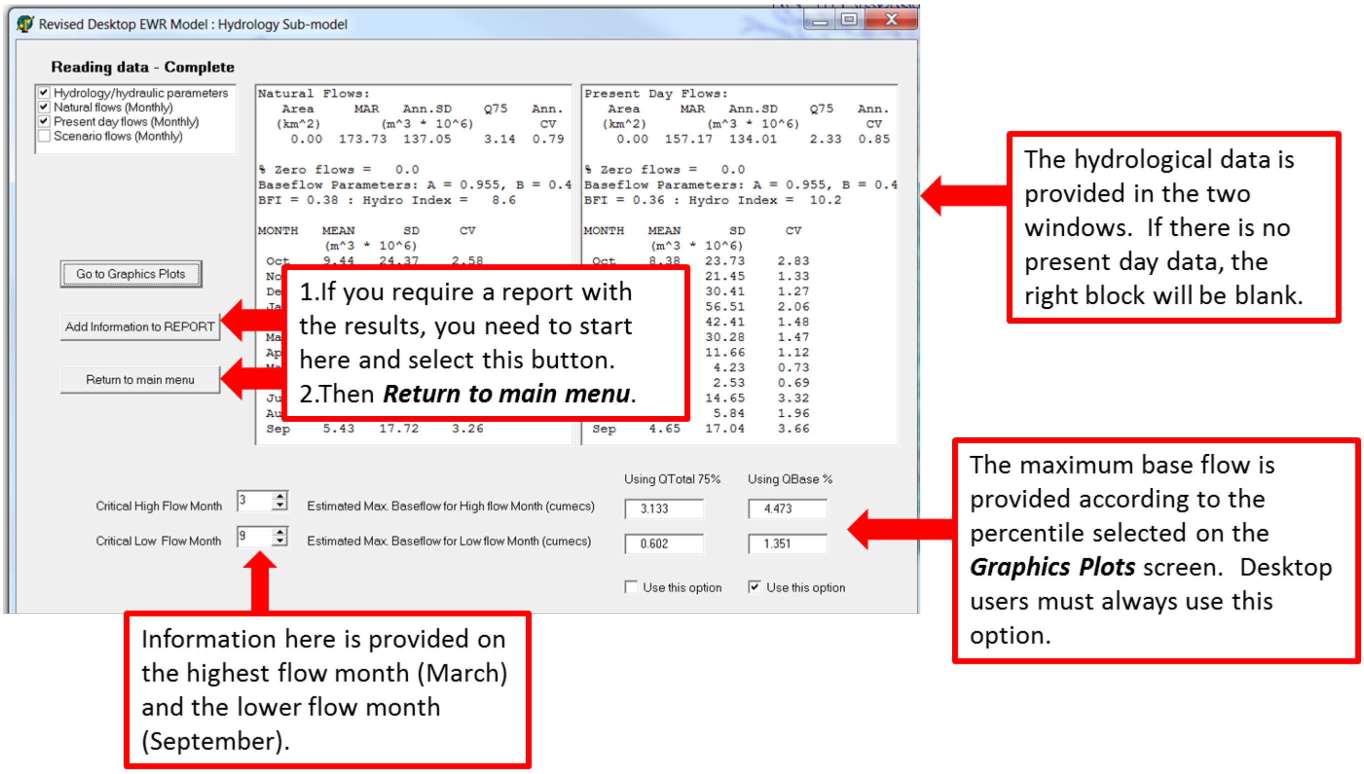
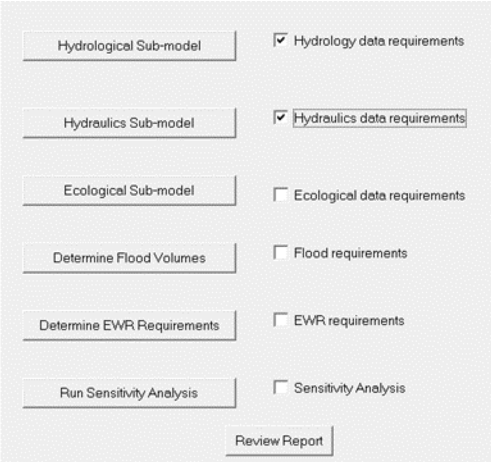


Figure 8.2 RDRM: The first screen of the hydrology sub-model

9 HYDRAULIC SUB-MODEL



The next sub-model to complete is the Hydraulic sub-model. This section focusses only on the use of the hydraulic sub-model when a cross-section and modelled hydraulics are not available. Options would differ were these data available.

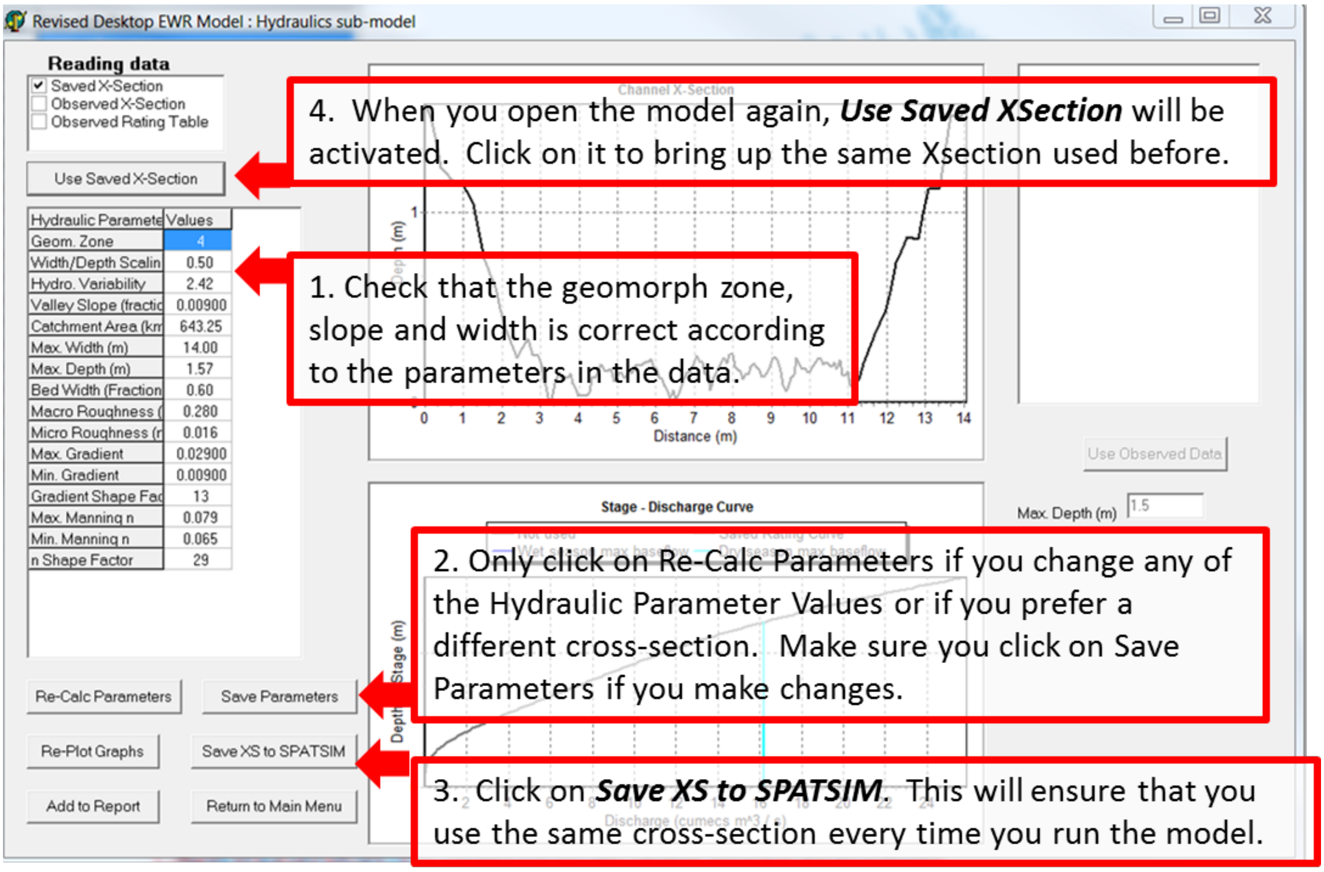
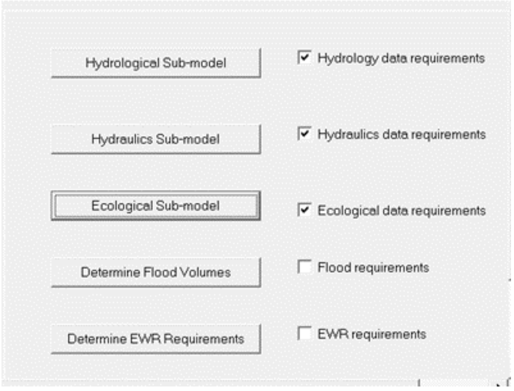


Figure 9.1 The main screen of the hydraulics sub-model

10 ECOLOGY (LOW FLOWS) SUB-MODEL



The next sub-model to complete is the Ecological sub-model. The section below focusses on that which the Desktop user will require. When used in a specialist environment, many changes can be made to incorporate specialist input. This will be explained in later chapters as well an explanation of how the model works (copied from the IWR manual (Denis Hughes)).

When the Ecological Sub-model is first activated, the following is asked:
"Current category shift parameters are NOT defaults. Do you want to restore defaults?? Yes/No

Reply "Yes" unless (default) shifts have been previously modified based on specialist application of the Ecological sub-model – which should generally not be the case at the Desktop application. Default settings include not aligning the maximum stress to Present Day.

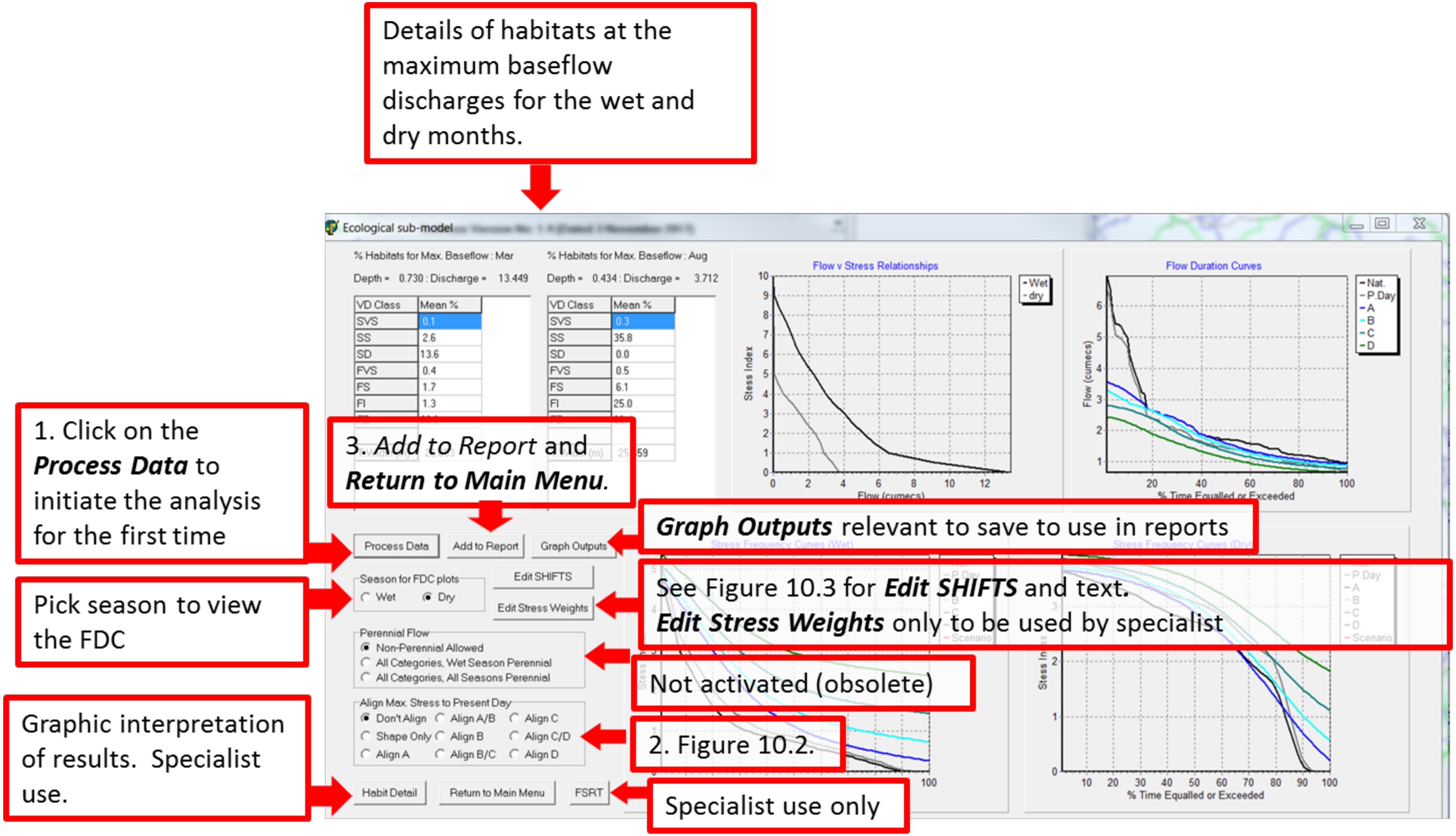
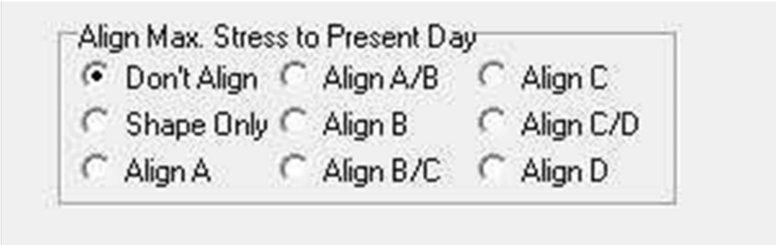


Figure 10.1 Viewing the Ecological Sub-model and adjusting changes where required



There are two main options for aligning the shape of the stress frequency curves to the Present Day condition.

The first is to use the shape of the Present Day curve only, but leave the end points associated with Natural (Shape Only).

The second is to align a specific ecological category. The maximum stress (for that category) is set to be the same value as the present day maximum stress and the other category maximum stress values calculated on the basis of standard separation distances. The low stress for a D category is set (by default) to 0.5 * the maximum stress. The shape of the category curves also approximate the shape of the present day curve.

Figure 10.2 Alignment of Maximum Stress to Present Day Hydrology

Edit shifts is a further option for aligning the EWRs to for example Present Day or to change the shifts of categories. Click on the Edit Shifts button and a screen will open (Figure 10.3) with the default shifts which you can modify in the column called Current High or Low. High refers to the high stress (left of the graph) and Low to the low stress on the right of the graph. Once you have made some changes, click on Save and the stress frequency curves will be adjusted according to the changes as well as the Flow Duration Curves. Once you have made all the changes required, you can Save and Exit.
NB, to ensure that you use these changes in future runs of the model, answer NO to the question that opens at the beginning of the Sub-model, i.e. you do not want to use your previous changes, you do NOT want to change to default.

You need a basic understanding of the Stress Frequency Curves to interpret the graph and to edit the shifts. You should also document the reason for your changes.

Some essential concepts to remember when interpreting Stress Frequency Curves are the following:

- Stress frequency curves are 'upside down' Flow Duration Curves.
- A 10 stress = zero flows and 0 stress = the highest flow considered in the stress index. Therefore, in a flow duration curve the left axis represent increasing flows whereas the stress index in the Stress Frequency Curves indicate decreasing flows (but increasing stress).
- As the report provides the flow requirements for all categories, you must adjust all the categories and not just the category you are interested in.

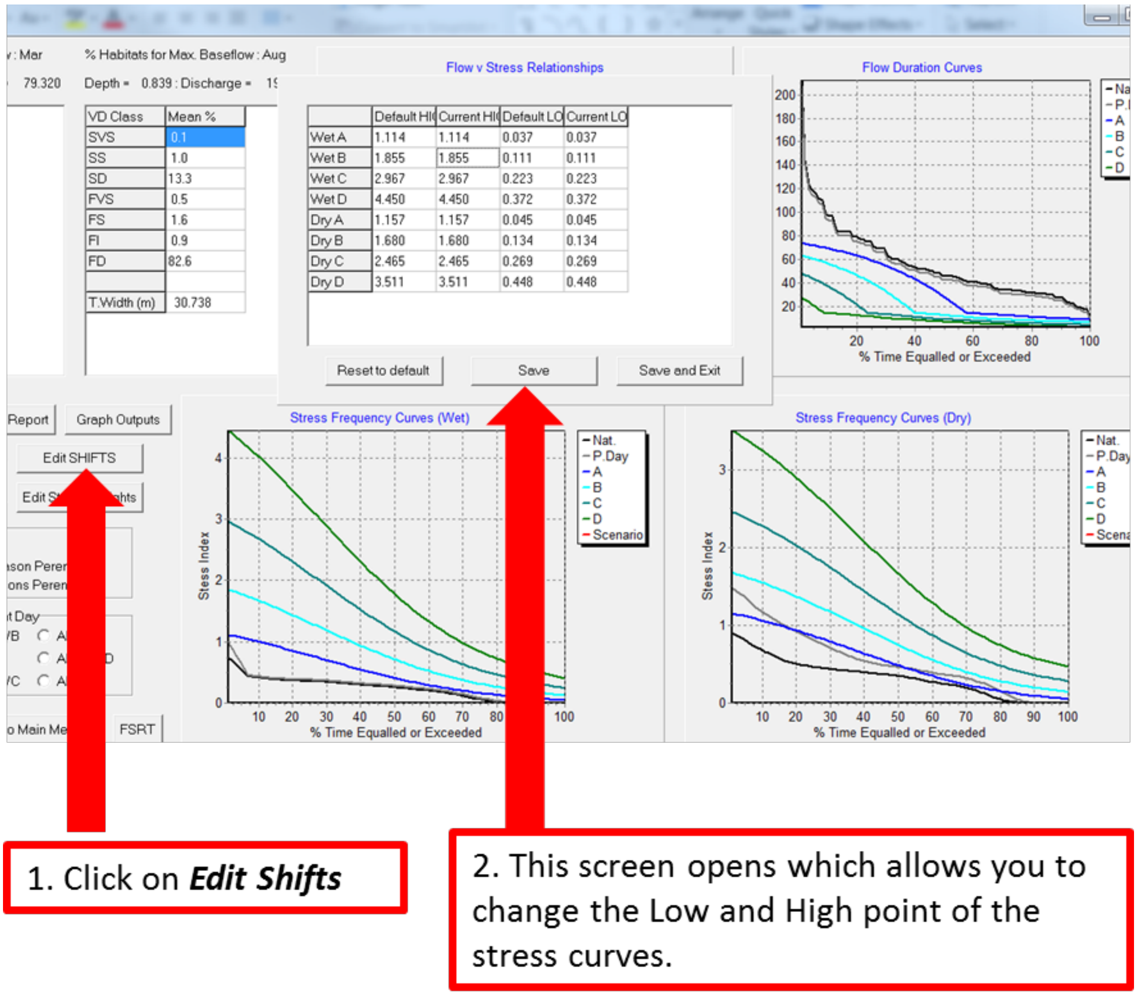
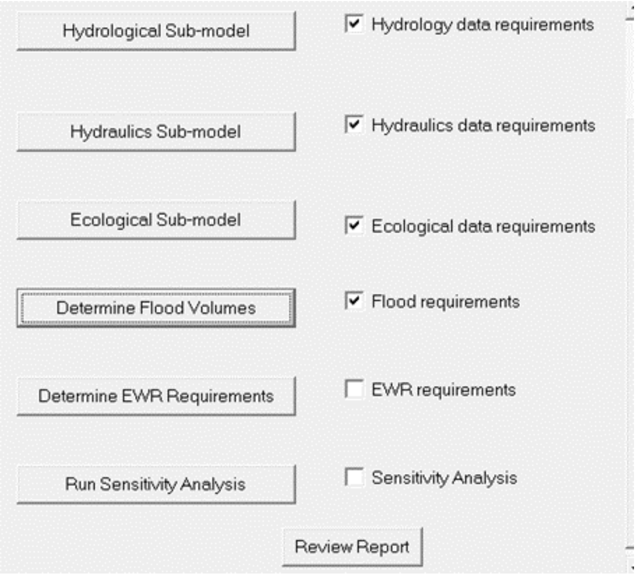


Figure 10.3 Edit Shifts

11 ECOLOGY (HIGH FLOWS) SUB-MODEL



Click on the ***Determine Flood Volumes*** button. The high flows are now based on a set of defined high flow event hydrographs. The default peaks are based on empirical equations using a combination of the maximum wet season baseflow, the bankfull discharge and the coeff. of variation of the highest flow month (see the Hydrology component). The time to peak and total duration are based on statistical relationships with catchment area, shape and slope. The default number of events and their expected frequency of occurrence are also preset. The screen and explanation are provided in **Figure 11.1**. More detail on the specialist use and explanations on how the sub-model works are supplied in later chapters.

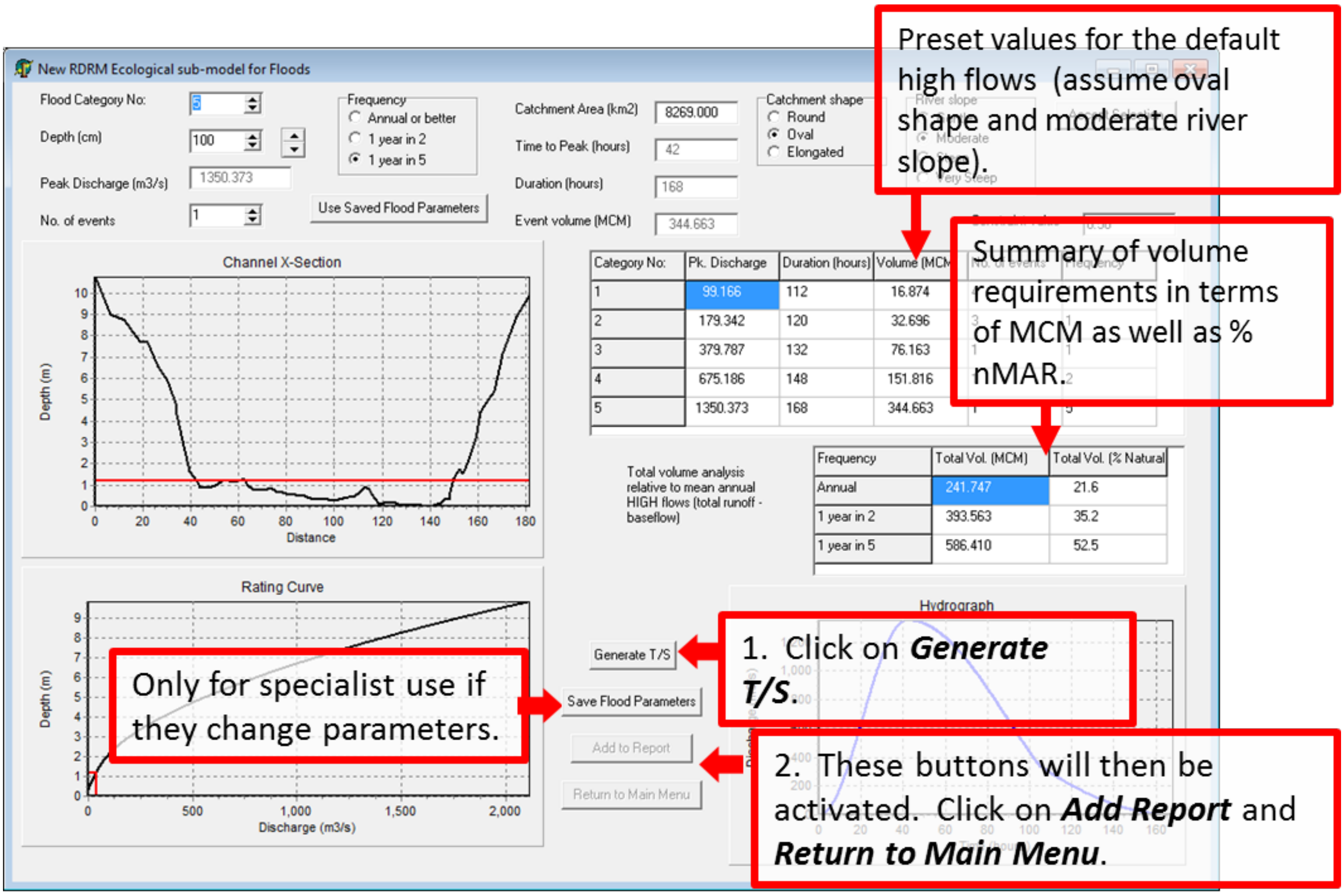
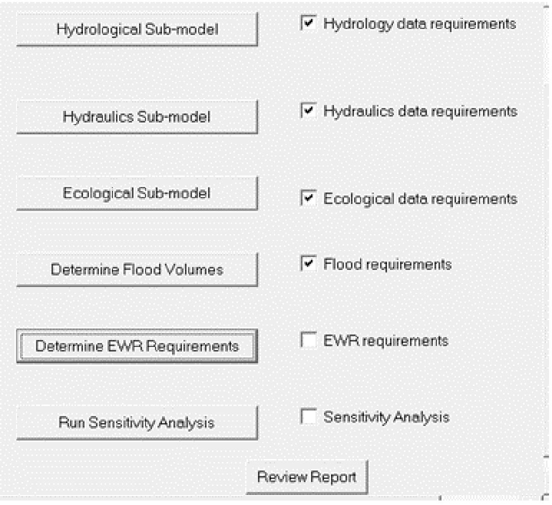


Figure 11.1 Ecology (High Flows) sub-model

12 GENERATING TIME SERIES AND THE REPORT



The next screen is ***Determine EWR Requirements*** and basically serves as the final result screen. All the results are displayed. The user can select various months to display data, can constrain the EWRs to natural or present day flows and can include or exclude the high (flood) flows. Lastly the user can save the results as time series and as flow duration tables as well as the report. **Figure 12.1** explains the different windows on the screen and **Figure 12.2** indicates the actions you need to take to produce the final report.

All the results can be reviewed and obtained from the report which can be reviewed and output clicking on the ***Review Report*** button.

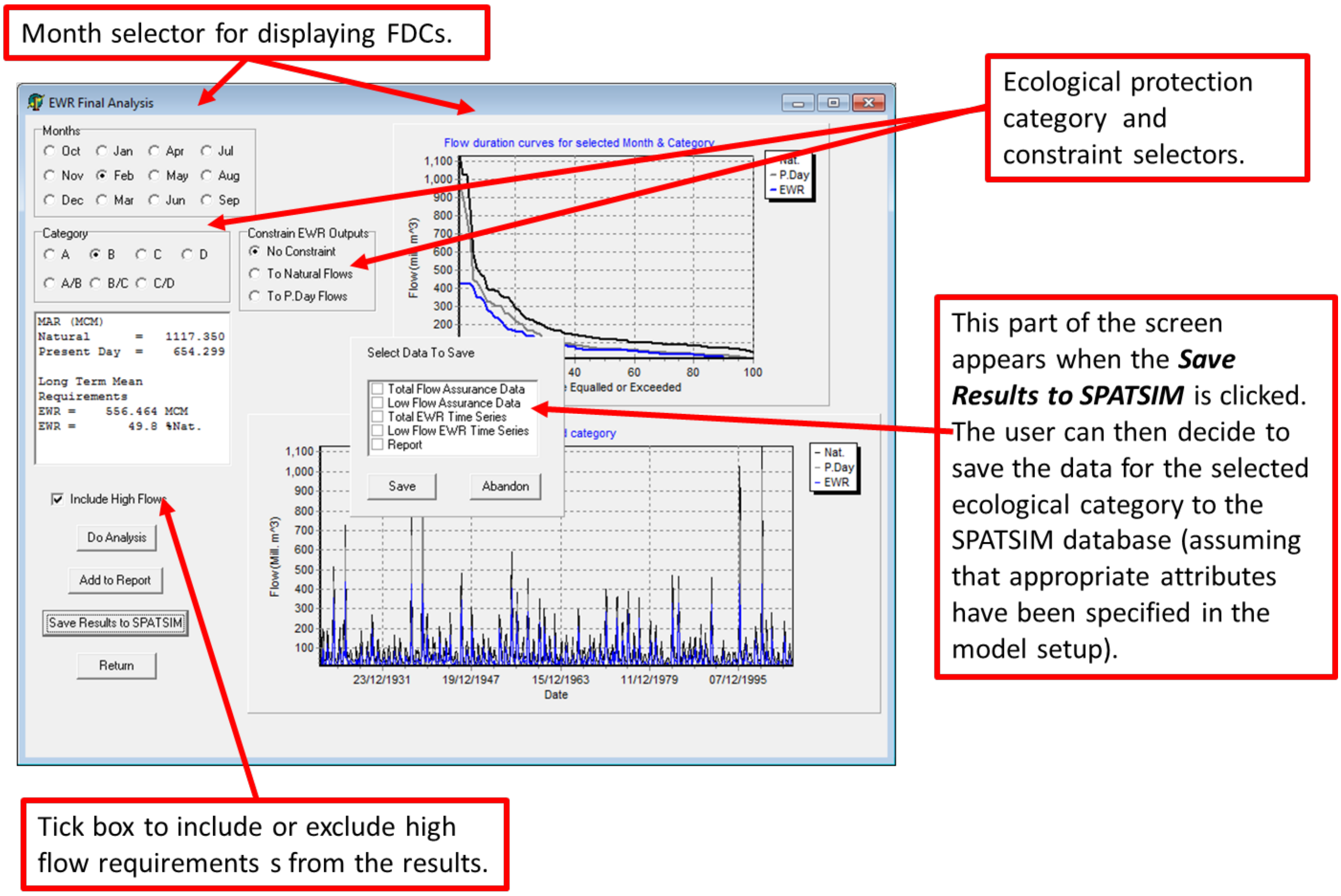


Figure 12.1 Final screen for generating the complete time series

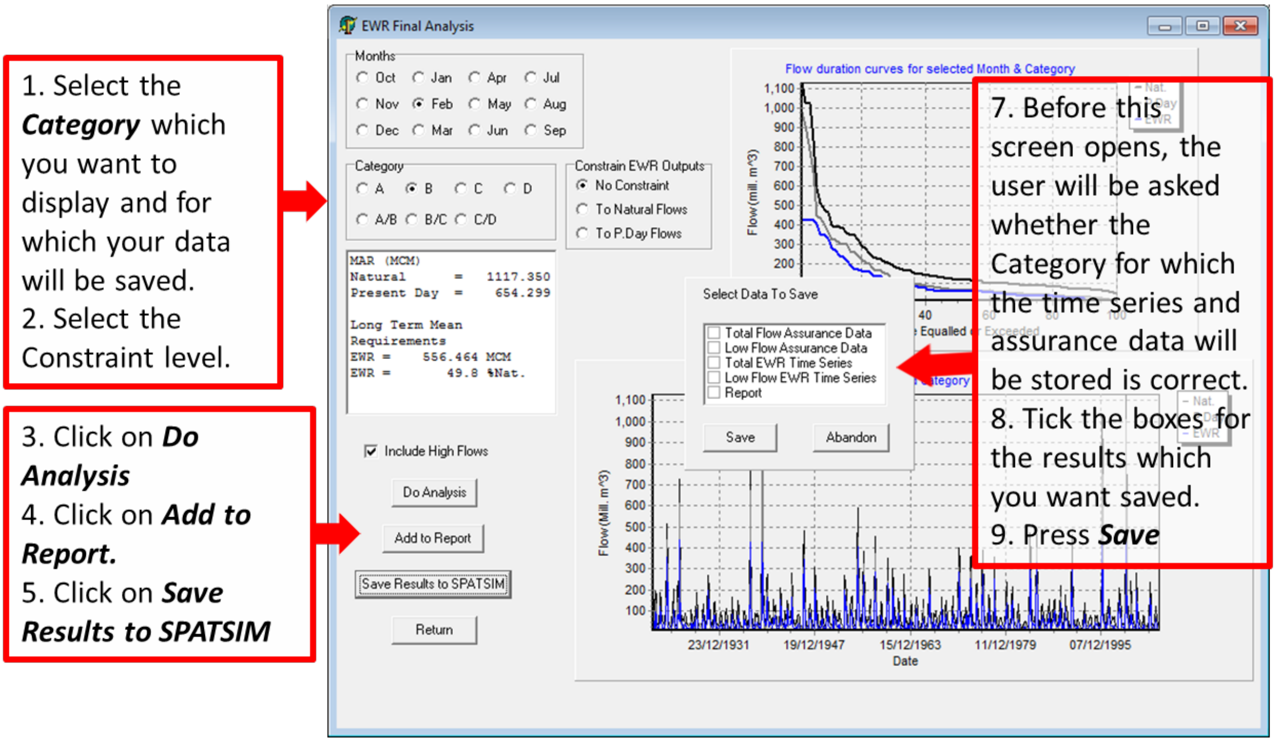


Figure 12.2 Actions required for producing final results

12.1 REVIEW REPORT

The report must be initiated (or reset) in the hydrology sub-model. The '***Add to Report'*** buttons in the other sub-models can be used to add all the details to the report.

Note that to output the report to user has to ***Review Report*** (after clicking on return) which is the last screen of the RDRM and then ***Output to file***. The user can then save the file as a text file in a known location.

The report pages with explanation blocks are provided below:

Revised Desktop Model outputs for site: TsitManua

HYDROLOGY DATA SUMMARY

Natural Flows: Present Day Flows:

Area (km^2)	MAR (m^3 * 10^6)	Ann.SD	Q75	Ann. CV	Area (km^2)	MAR (m^3 * 10^6)	Ann.SD	Q75	Ann. CV
0.00	438.04	183.70	6.68	0.42	0.00	413.16	178.59	5.84	0.43

% Zero flows = 0.0 % Zero flows = 0.0

Baseflow Parameters: A = 0.960, B = 0.43Baseflow Parameters: A = 0.960, B = 0.430

BFI = 0.35 : Hydro Index = 6.2 BFI = 0.34 : Hydro Index = 6.6

MONTH	MEAN (m^3 * 10^6)	SD	CV	MONTH	MEAN (m^3 * 10^6)	SD	CV
Oct	21.41	22.92	1.07	Oct	19.86	22.01	1.11
Nov	39.69	37.13	0.94	Nov	37.37	35.92	0.96
Dec	54.43	46.09	0.85	Dec	51.38	44.62	0.87
Jan	66.07	51.92	0.79	Jan	62.44	50.55	0.81
Feb	76.81	54.60	0.71	Feb	73.13	53.11	0.73
Mar	79.48	55.73	0.70	Mar	75.93	54.44	0.72
Apr	41.16	35.85	0.87	Apr	39.02	34.81	0.89
May	14.90	14.85	1.00	May	13.92	14.34	1.03
Jun	10.54	13.75	1.30	Jun	9.68	13.23	1.37
Jul	10.64	16.70	1.57	Jul	9.65	16.19	1.68
Aug	10.35	13.68	1.32	Aug	9.36	13.22	1.41
Sep	12.57	19.33	1.54	Sep	11.43	18.73	1.64

Hydrology statistics for natural and present day flows

Critical months: WET : Mar, DRY : Aug
Using 15th percentile of FDC of separated baseflows
Max. baseflows (m3/s): WET : 13.077, DRY : 3.569

Wettest and driest months, and the maximum base flow used. This is important information if one has to rerun the model

HYDRAULICS DATA SUMMARY

Geomorph. Zone 5
Width/Depth scaling 0.50
Max. Channel width (m) 35.00
Max. Channel Depth (m) 2.79
Max. Channel Discharge (m3/s) between 110.120 and 116.537

Important hydraulic parameter information to use if the model has to be rerun.

FLOW - STRESSOR RESPONSE DATA SUMMARY

Table of Stress weightings

Season	Wet	Dry
Stress at 0 FS:	9	5
FS Weight:	3	3
FI Weight:	4	1
FD Weight:	5	0

Weights based on specific fish species which the user provided as input. Important to use if the model has to be rerun.

Table of flows (m3/2) v stress index

Stress	Wet Season Flow	Dry Season Flow
0.0	13.387	3.690
0.5	8.972	3.329
1.0	6.959	2.821
1.5	6.150	2.535
2.0	5.164	2.270
2.5	4.538	1.824
3.0	3.992	1.451
3.5	3.408	0.831
4.0	2.827	0.452
4.5	2.453	0.240
5.0	2.068	0.045
5.5	1.757	0.041
6.0	1.435	0.036
6.5	1.130	0.032
7.0	0.869	0.027
7.5	0.647	0.023
8.0	0.431	0.018
8.5	0.240	0.014
9.0	0.045	0.009
9.5	0.023	0.005
10.0	0.000	0.000

Weights based on specific fish species which the user provided as input. Important to use if the model has to be rerun.

Table of default/altered SHIFT factors for the Stress Frequency Curves

Category	High SHIFT Default	High SHIFT Altered	Low SHIFT Default	Low SHIFT Altered
Wet season				
A	4.619	4.629	0.228	0.416
A/B	4.680	4.690	0.456	0.644
B	4.741	4.751	0.684	0.872
B/C	4.833	4.843	1.025	1.214
C	4.925	4.935	1.367	1.556
C/D	5.048	5.057	1.823	2.012
D	5.170	5.180	2.279	2.467
Dry season				
A	3.430	3.483	0.170	0.296
A/B	3.463	3.516	0.340	0.466
B	3.496	3.549	0.510	0.636
B/C	3.546	3.599	0.764	0.890
C	3.596	3.649	1.019	1.145
C/D	3.662	3.715	1.359	1.485
D	3.729	3.782	1.698	1.824

Relevant for specialist use. If category shifts are adjusted, it will be reflected.

Perenniality Rules
Non-Perennial Allowed

Function in model not yet active.

Alignment of maximum stress to Present Day stress
C Category Aligned

Record of alignment.

HIGH FLOW REQUIREMENT SUMMARY

Bankfull channel discharge (m3/s) = 113.328

Flood event requirements

Class	Frequency	Peak(m3/s)	Duration(hours)	N. Events	Volume(MCM)
1	Annual	17.548	88	4	2.346
2	Annual	37.888	104	3	5.986
3	Annual	59.631	116	1	10.509
4	1:2 year	79.489	124	1	14.975
5	1:5 year	135.386	148	1	30.442

Flood requirements have been constrained to a maximum of 0.18 of natural high flows

Specialist use. If floods are provided by specialists, the data will be stored here.

FINAL RESERVE SUMMARY DETAILS

EWR (low and total Flows) are constrained to be below Present Day Flows

Levels set for constraining to natural or present day recorded here.

Long term mean flow requirements (Mill. m3 and %MAR)

Category	Low Flows Mill. m3	Low Flows %MAR	Total Flows Mill. m3	Total Flows %MAR
A	106.746	24.4	170.686	39.0
A/B	100.737	23.0	162.972	37.2
B	95.638	21.8	155.411	35.5
B/C	89.249	20.4	146.545	33.5
C	82.892	18.9	136.732	31.2
C/D	74.946	17.1	124.890	28.5
D	67.634	15.4	114.087	26.0

Important summary statistics of EWR results to be used in report and other tables.

FLOW DURATION and RESERVE ASSURANCE TABLES

Columns are FDC percentage points:

Natural Total flow duration curve (mill. m3)

	10	20	30	40	50	60	70	80	90	99
Oct	50.570	32.150	23.635	17.790	13.000	9.980	8.445	6.080	5.245	2.940
Nov	101.725	62.850	49.260	38.110	25.300	18.390	15.560	11.090	7.195	3.565
Dec	112.820	98.540	76.580	57.210	35.720	29.970	22.560	16.960	8.470	1.681
Jan	153.250	103.710	84.580	62.980	47.200	40.370	33.685	28.510	16.550	5.475
Feb	153.020	123.520	103.145	91.330	70.670	48.520	36.045	25.040	18.720	11.084
Mar	161.320	108.110	91.625	81.660	70.710	52.280	46.260	36.050	24.690	11.691
Apr	85.500	55.860	49.555	44.390	30.360	26.730	19.520	14.250	10.205	3.690
May	28.965	24.050	15.625	11.800	10.565	8.990	7.720	5.450	4.690	3.453
Jun	20.200	13.720	9.130	7.660	5.960	5.100	4.595	4.070	3.500	2.688
Jul	18.455	10.990	9.695	6.660	5.615	5.050	4.315	3.810	3.290	2.457
Aug	23.295	13.120	8.420	7.030	5.485	4.740	4.145	3.310	2.995	2.539
Sep	30.855	15.260	11.130	8.740	6.335	6.000	4.590	3.690	2.920	2.190

Natural Baseflow flow duration curve (mill. m3)

	10	20	30	40	50	60	70	80	90	99
Oct	14.089	10.284	8.444	6.898	5.877	5.544	4.788	3.980	3.523	2.840
Nov	22.171	16.454	13.025	10.334	9.411	7.290	6.614	5.685	4.448	3.293
Dec	27.199	21.962	18.705	15.201	11.803	10.080	8.530	7.122	5.174	1.681
Jan	31.390	27.178	21.486	18.574	15.206	13.872	12.048	9.475	7.043	3.068
Feb	37.858	31.354	25.362	22.492	18.947	17.143	14.236	12.147	9.359	5.202
Mar	41.150	32.210	27.116	24.151	21.018	19.731	17.436	14.993	11.972	6.059
Apr	33.225	27.264	22.497	20.017	17.604	15.484	12.919	11.148	8.180	3.690
May	19.412	15.957	12.796	11.570	10.227	8.700	6.625	5.370	4.690	3.453
Jun	15.305	11.010	8.310	6.850	5.439	4.860	4.590	4.070	3.475	2.688
Jul	11.771	9.274	6.646	5.780	5.195	4.515	4.201	3.698	3.290	2.457
Aug	12.608	7.040	6.318	5.050	4.553	4.250	3.764	3.240	2.935	2.536
Sep	11.247	7.400	6.089	5.580	4.995	3.970	3.685	3.270	2.737	

Natural flow duration for the total and separated base flows provided as an assurance table

Category Low Flow Assurance curves (mill. m3)

A Category

	10	20	30	40	50	60	70	80	90	99
Oct	9.435	9.394	7.525	6.079	5.162	4.157	3.550	3.085	2.783	2.218
Nov	13.765	13.502	10.847	8.878	7.343	5.418	4.637	4.079	3.459	2.928
Dec	17.457	17.414	15.093	12.455	9.901	7.683	6.228	5.179	3.982	1.357
Jan	20.173	19.966	17.043	14.507	12.248	10.200	8.398	6.729	4.944	2.984
Feb	21.232	20.832	17.205	15.580	13.656	11.211	8.979	7.465	5.884	4.370
Mar	23.524	22.013	20.071	18.146	16.644	14.182	12.041	9.941	7.683	6.059
Apr	19.565	19.140	16.821	15.094	13.569	10.901	8.803	7.507	5.568	3.251
May	13.620	13.569	11.614	9.730	8.373	6.459	4.951	4.120	3.568	2.882
Jun	10.019	9.580	7.377	5.969	4.576	3.588	3.261	3.026	2.679	2.118
Jul	8.541	8.454	6.099	5.210	4.401	3.464	3.068	2.847	2.540	1.819
Aug	8.121	6.821	5.774	4.618	3.922	3.203	2.759	2.503	2.315	1.907
Sep	7.470	6.870	4.877	4.711	4.068	2.918	2.574	2.396	2.059	1.521

A/B Category

	10	20	30	40	50	60	70	80	90	99
Oct	9.109	9.074	7.238	5.879	4.969	3.961	3.384	2.940	2.655	2.218
Nov	13.015	12.817	10.319	8.558	7.045	5.158	4.427	3.893	3.305	2.839
Dec	16.268	16.233	14.143	11.957	9.468	7.306	5.955	4.949	3.808	1.357
Jan	18.437	18.255	15.798	13.886	11.670	9.688	8.050	6.445	4.739	2.882
Feb	19.451	19.070	15.807	14.845	12.949	10.634	8.623	7.170	5.673	4.266
Mar	21.123	19.671	18.304	17.278	15.696	13.491	11.620	9.578	7.466	6.059
Apr	17.880	17.534	15.598	14.423	12.890	10.345	8.445	7.203	5.351	3.251
May	12.932	12.903	11.027	9.373	8.024	6.146	4.727	3.931	3.410	2.882
Jun	9.587	9.237	7.094	5.773	4.407	3.420	3.109	2.884	2.555	2.118
Jul	8.303	8.189	5.889	5.043	4.240	3.302	2.924	2.712	2.511	1.819
Aug	7.716	6.650	5.555	4.479	3.763	3.053	2.628	2.383	2.247	1.907
Sep	7.181	6.622	4.601	4.561	3.920	2.774	2.462	2.285	1.975	1.521

EWR rules (old .rul table) provided for the LOW flows for each category. Only 2 categories demonstrated here.

Category Total Flow Assurance curves (mill. m3)

A Category

	10	20	30	40	50	60	70	80	90	99
Oct	15.421	15.380	9.871	8.425	7.508	4.157	3.550	3.085	2.783	2.218
Nov	27.878	24.011	16.833	14.864	13.329	7.764	6.983	4.079	3.459	2.928
Dec	47.899	34.961	25.602	18.441	15.887	13.669	8.574	7.525	3.982	1.357
Jan	46.350	30.644	27.552	20.493	18.234	16.186	14.384	11.824	7.290	2.984
Feb	52.847	51.274	34.752	28.435	24.165	17.197	14.965	9.811	8.230	4.370
Mar	53.966	52.455	38.912	28.655	22.630	20.168	18.027	15.927	10.029	6.059
Apr	27.897	25.126	22.807	17.440	15.915	13.247	9.696	7.507	5.568	3.251
May	15.966	15.915	11.614	9.730	8.373	6.459	4.951	4.120	3.568	2.882
Jun	12.365	9.580	7.377	5.969	4.576	3.588	3.261	3.026	2.679	2.118
Jul	10.887	8.454	6.099	5.210	4.401	3.464	3.068	2.847	2.540	1.819
Aug	10.467	9.167	5.774	4.618	3.922	3.203	2.759	2.503	2.315	1.907
Sep	11.636	9.216	5.669	4.711	4.068	2.918	2.574	2.396	2.059	1.521

A/B Category

	10	20	30	40	50	60	70	80	90	99
Oct	15.095	15.060	9.584	8.225	7.315	3.961	3.384	2.940	2.655	2.218
Nov	27.128	21.149	16.305	14.544	10.828	7.504	6.773	3.893	3.305	2.839
Dec	46.710	33.994	24.652	17.943	15.454	13.292	8.301	7.295	3.808	1.357
Jan	43.110	30.227	25.218	19.872	17.656	15.674	14.036	8.791	6.960	2.882
Feb	51.066	49.512	33.354	27.700	23.269	16.620	14.609	9.516	8.019	4.266
Mar	51.565	49.710	36.385	25.610	21.682	19.477	17.606	15.512	9.812	6.059
Apr	26.212	23.520	21.584	16.769	15.236	12.691	10.769	7.203	5.351	3.251
May	15.278	15.249	11.027	9.373	8.024	6.146	4.727	3.931	3.410	2.882
Jun	9.587	9.237	7.094	5.773	4.407	3.420	3.109	2.884	2.555	2.118
Jul	10.649	8.189	5.889	5.043	4.240	3.302	2.924	2.712	2.511	1.819
Aug	10.062	8.996	5.555	4.479	3.763	3.053	2.628	2.383	2.247	1.907
Sep	11.347	8.968	5.774	4.561	3.920	2.774	2.462	2.285	1.975	1.521

EWR rules (old .rul table) provided for the TOTAL flows for each category. Only 2 categories demonstrated here.

12.2 TIME SERIES AND ASSURANCE DATA

To extract the above data which has been saved to the SPATSIM database, the following must be done:

- Highlight the correct ***Attribute***
- Click the ***view attribute*** icon in the top menu
- Click on the site and open
- Click on ***Output to file***
- Select where it should be saved and save (Figure 12.3).

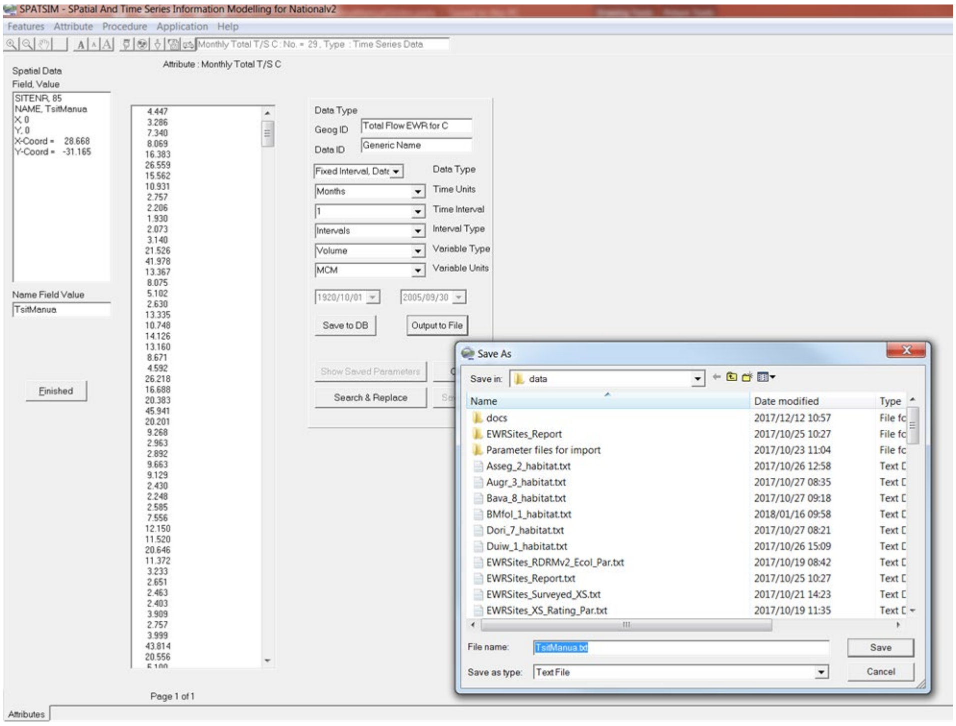


Figure 12.3 Screen showing how to output and save attributes such as a specific time series

13 SENSITIVITY ANALYSIS

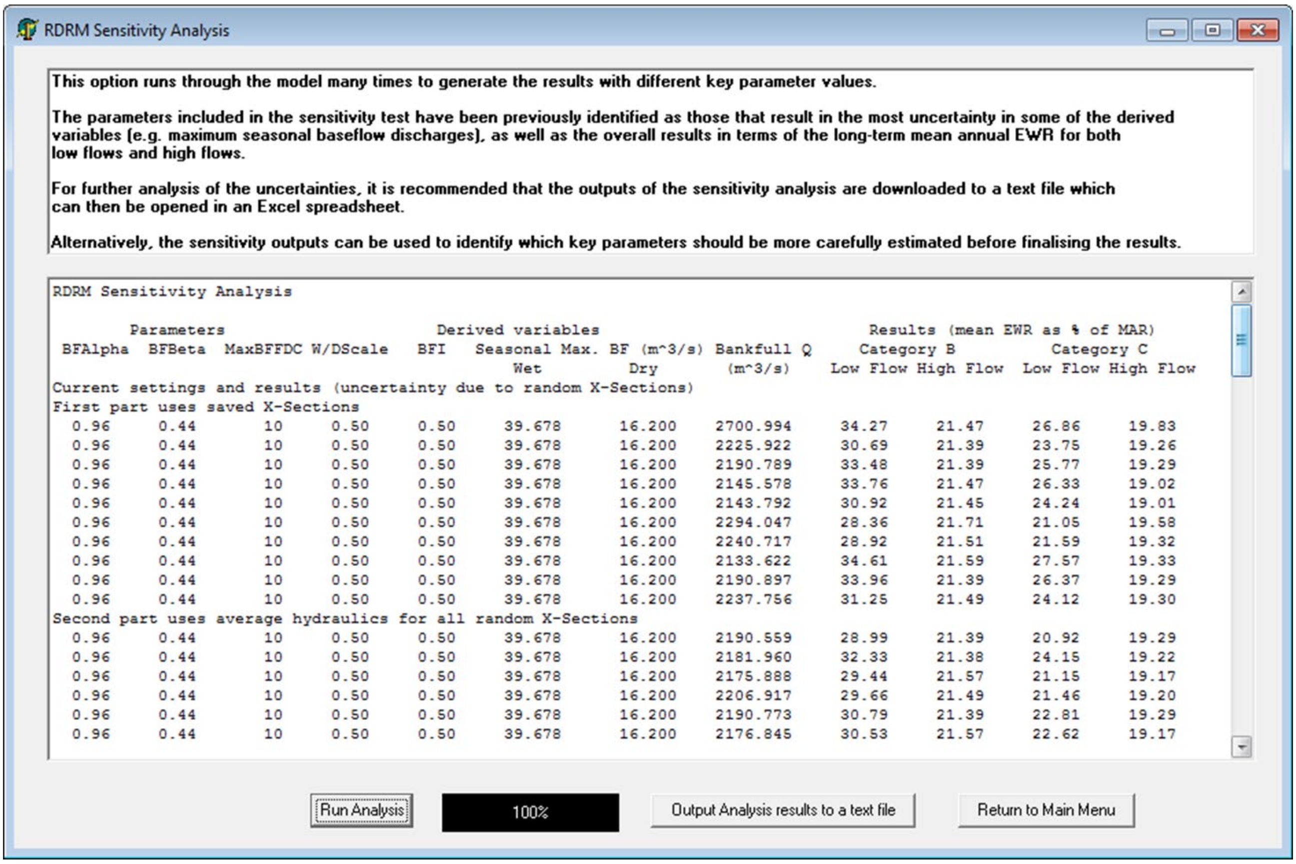
The model results can be sensitive to some of the input parameter values and this feature has been added in response to a suggestion by Mr Pieter van Rooyen of WRP Consulting Engineers.

The key parameters are the baseflow separation alpha and beta parameters, the % point used to fix the maximum baseflow values and the width/depth scaling parameter that determines bankfull depth. The model is also often sensitive to the channel X-section shape and how this is used. The Save X-Section and Use Saved X-Section options prevent variations in results between model runs (assuming no other parameters are changed). However, using the outputs might still be sensitive to the shape of the saved section, rather than using hydraulic data based on the mean characteristics of the 25 random sections that are initially generated.

The sensitivity analysis must be initiated after the model has been run at least once to ensure that all the appropriate variables are quantified.

The analysis starts (**Figure 13.1**) with fixed parameter values and examines the results of using different single X-sections, followed by using the mean hydraulic characteristics of the 25 randomly generated X-sections.

The next part combines ranges of BFα (0.95 to 0.98), BFβ (0.42 to 0.44), FDC %Pt used for maximum baseflows (5, 10, 15, 20) and the width/depth scaling parameter (0.45, 0.5, 0.55) to generate 108 sample results. A new X-section is generated and saved each time the width/depth scaling parameter is changed (to eliminate uncertainties due to different X-sectional shapes).



Parameters				Derived variables				Results (mean EWR as % of MAR)			
BFAlpha	BFBeta	MaxBFFDC	W/DScale	BFI	Seasonal Max. BF (m^3/s) Wet	Seasonal Max. BF (m^3/s) Dry	Bankfull Q (m^3/s)	Category B Low Flow	Category B High Flow	Category C Low Flow	Category C High Flow
Current settings and results (uncertainty due to random X-Sections)											
First part uses saved X-Sections											
0.96	0.44	10	0.50	0.50	39.678	16.200	2700.994	34.27	21.47	26.86	19.83
0.96	0.44	10	0.50	0.50	39.678	16.200	2225.922	30.69	21.39	23.75	19.26
0.96	0.44	10	0.50	0.50	39.678	16.200	2190.789	33.48	21.39	25.77	19.29
0.96	0.44	10	0.50	0.50	39.678	16.200	2145.578	33.76	21.47	26.33	19.02
0.96	0.44	10	0.50	0.50	39.678	16.200	2143.792	30.92	21.45	24.24	19.01
0.96	0.44	10	0.50	0.50	39.678	16.200	2294.047	28.36	21.71	21.05	19.58
0.96	0.44	10	0.50	0.50	39.678	16.200	2240.717	28.92	21.51	21.59	19.32
0.96	0.44	10	0.50	0.50	39.678	16.200	2133.622	34.61	21.59	27.57	19.33
0.96	0.44	10	0.50	0.50	39.678	16.200	2190.897	33.96	21.39	26.37	19.29
0.96	0.44	10	0.50	0.50	39.678	16.200	2237.756	31.25	21.49	24.12	19.30
Second part uses average hydraulics for all random X-Sections											
0.96	0.44	10	0.50	0.50	39.678	16.200	2190.559	28.99	21.39	20.92	19.29
0.96	0.44	10	0.50	0.50	39.678	16.200	2181.960	32.33	21.38	24.15	19.22
0.96	0.44	10	0.50	0.50	39.678	16.200	2175.888	29.44	21.57	21.15	19.17
0.96	0.44	10	0.50	0.50	39.678	16.200	2206.917	29.66	21.49	21.46	19.20
0.96	0.44	10	0.50	0.50	39.678	16.200	2190.773	30.79	21.39	22.81	19.29
0.96	0.44	10	0.50	0.50	39.678	16.200	2176.845	30.53	21.57	22.62	19.17

Figure 13.1 RDRM sensitivity analysis

The results can be downloaded to a text file for further analysis. It is assumed that this will be done in an Excel spreadsheet to look for such things as the maximum range of results for different type of changes. These results may inform the user about which parameter values should be estimated more carefully, or can simply be used to approximately quantify ‘confidence limits’.

The low flow ecological weights and shifts are NOT included in the sensitivity analysis as it is assumed that these will be based on ecological information. Any sensitivity effects of these values will still have to be identified by repeated runs of the model.

14 SPECIALIST USE: HYDRAULIC SUB-MODEL

The hydraulic sub-model allows for the (specialist) use of surveyed cross-sections and modelled rating relationship information. The surveyed cross-section data is imported to an appropriately-named attribute (e.g. Surveyed XS) associated with the site (point) feature (**Figure 14.1**); the data is imported from a space-delimited text file containing two columns (chainage and elevation); data points (rows) are terminated with -999 -999; and up to 400 chainage-elevation ordinates are permitted.

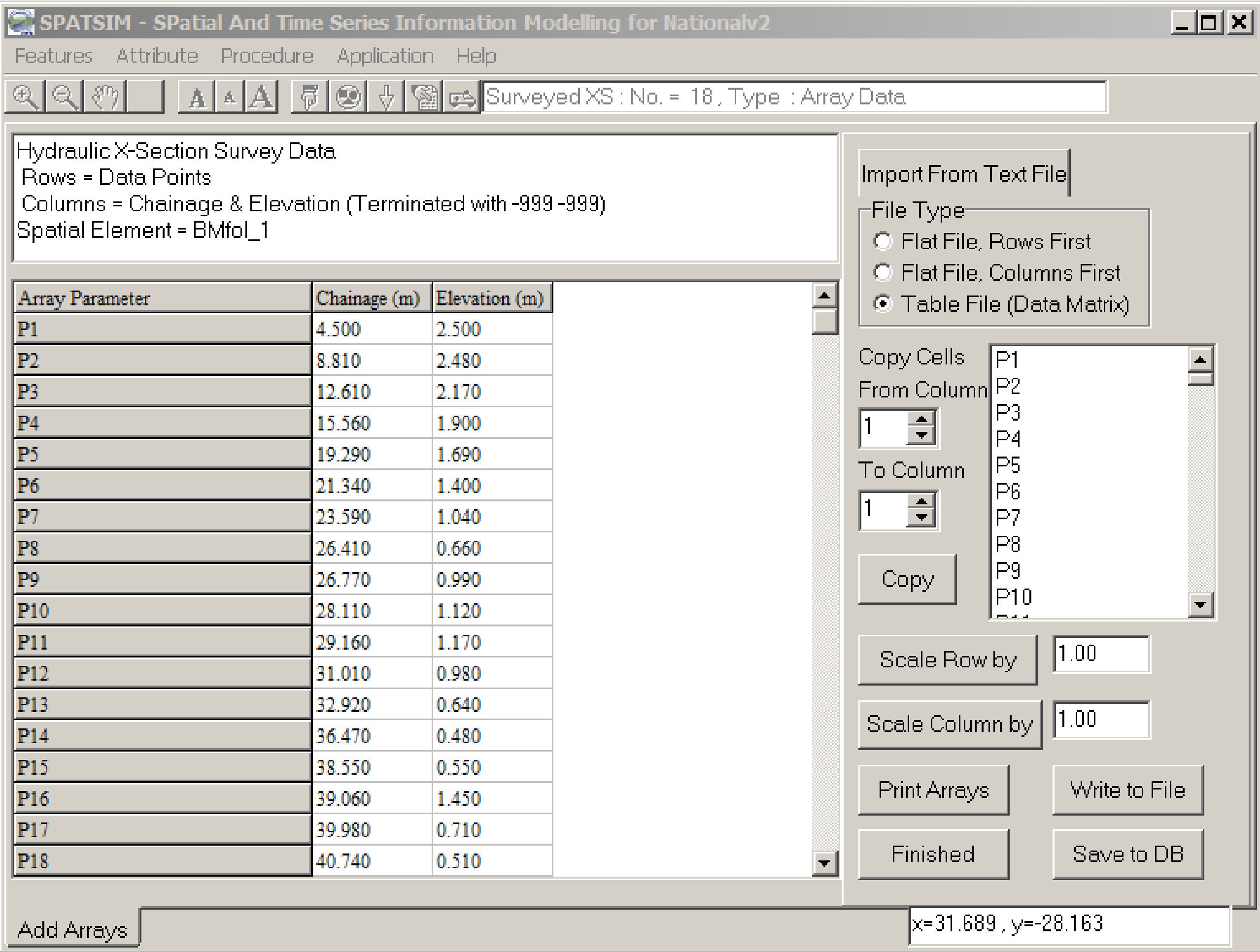


Figure 14.1 Surveyed cross-section attribute data

The modelled (outside of the RDRM) rating information is entered in an appropriately-named attribute (e.g. XS Rating Data) associated with the site (point) feature (**Figure 14.2**). The rating information is in the form of coefficients (*a*, *b* and *c*) in the power relationship given by:

$$y = aQ^b + c$$

where *y* is the depth (in m) and *Q* is the discharge (in m^3/s). Although these coefficients may be imported from a space delimited text file which is useful when dealing with many sites, for few sites it is easiest to enter the data manually into the site's attribute table – an example of which is illustrated in **Figure 14.2**. Further to the rating curve coefficients, multiple relationships may be used which require rating numbers and the maximum discharge for each relationship. The channel number and start/end chainages are from previous software developments, and should be 1 and -9, respectively.

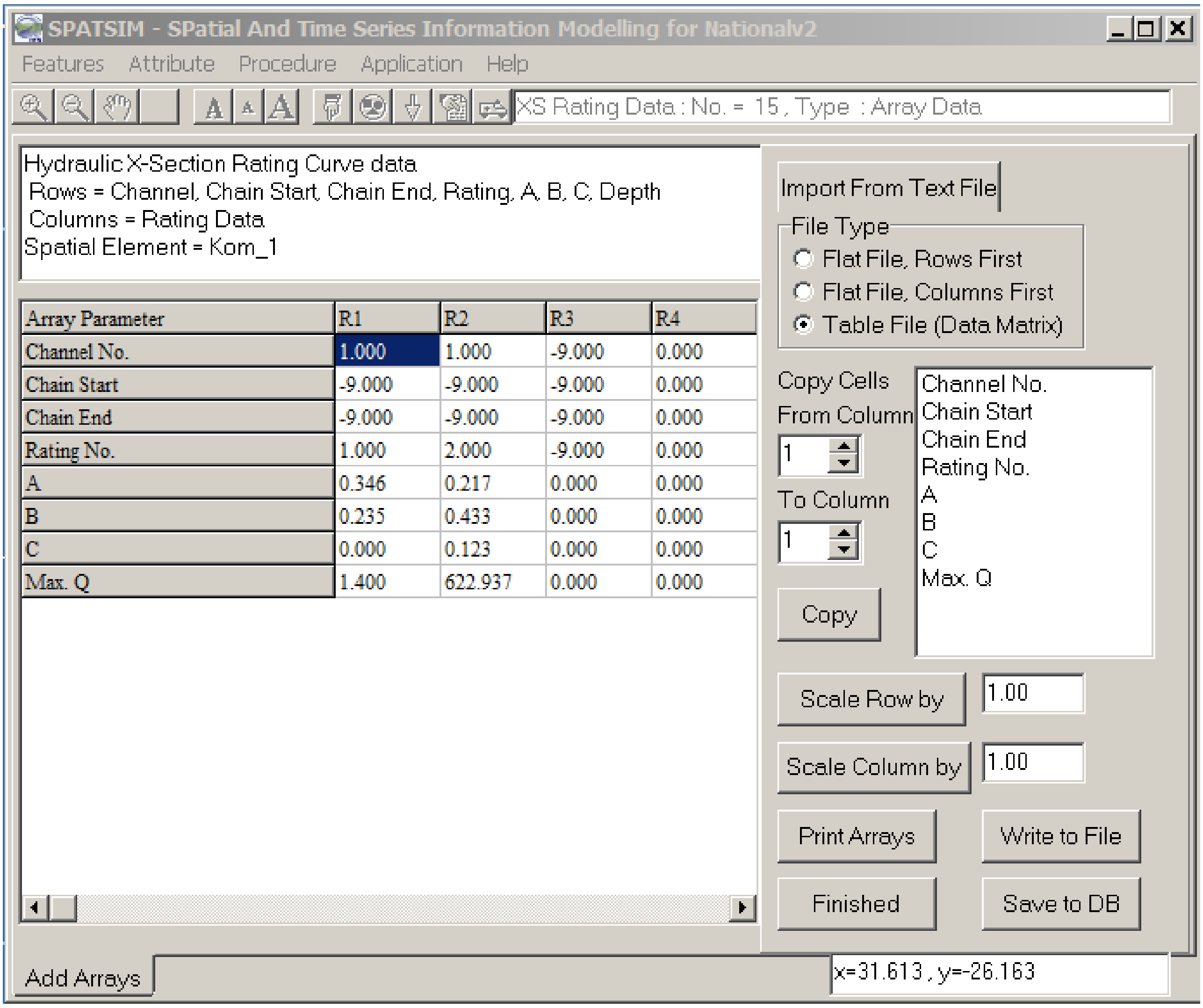


Figure 14.2 Surveyed cross-section attribute data

For use of observed data in the hydraulics sub-model, optional data inputs of an RDRM run, namely in this case: "9. Surveyed channel X-section" and "10. Stage-Discharge parameters" (refer to **Table 6.1**) must be linked to the cross-section (**Figure 14.1**) and rating (**Figure 14.2**) attribute data.

When executing the Hydraulics sub-model with observed hydraulic information, the relevant tick boxes in the top-left window ("Reading data") are indicated (refer to **Figure 14.3**). To use observed hydraulic data in the computations, it is necessary to press the "***Use Observed data***" button, which then displays the surveyed cross-section and "***observed rating curve***" (if it is available and has been linked to the run). The plotted "***calculated rating curve***" is the desktop relationship, and certain values need to be modified to align it with the observed curve. These values are listed in the bottom-right window and include: the maximum and minimum gradient and resistances together with their shape factors. Note, "calculated rating curve" parameters need to be saved after changes are made; the observed rating curve should include high flows (up to the 1:5 flood) and the calculated rating curve aligned to it over the entire flow range – since the rating curve is used in the Ecological sub-models for low and high flows, that follow.

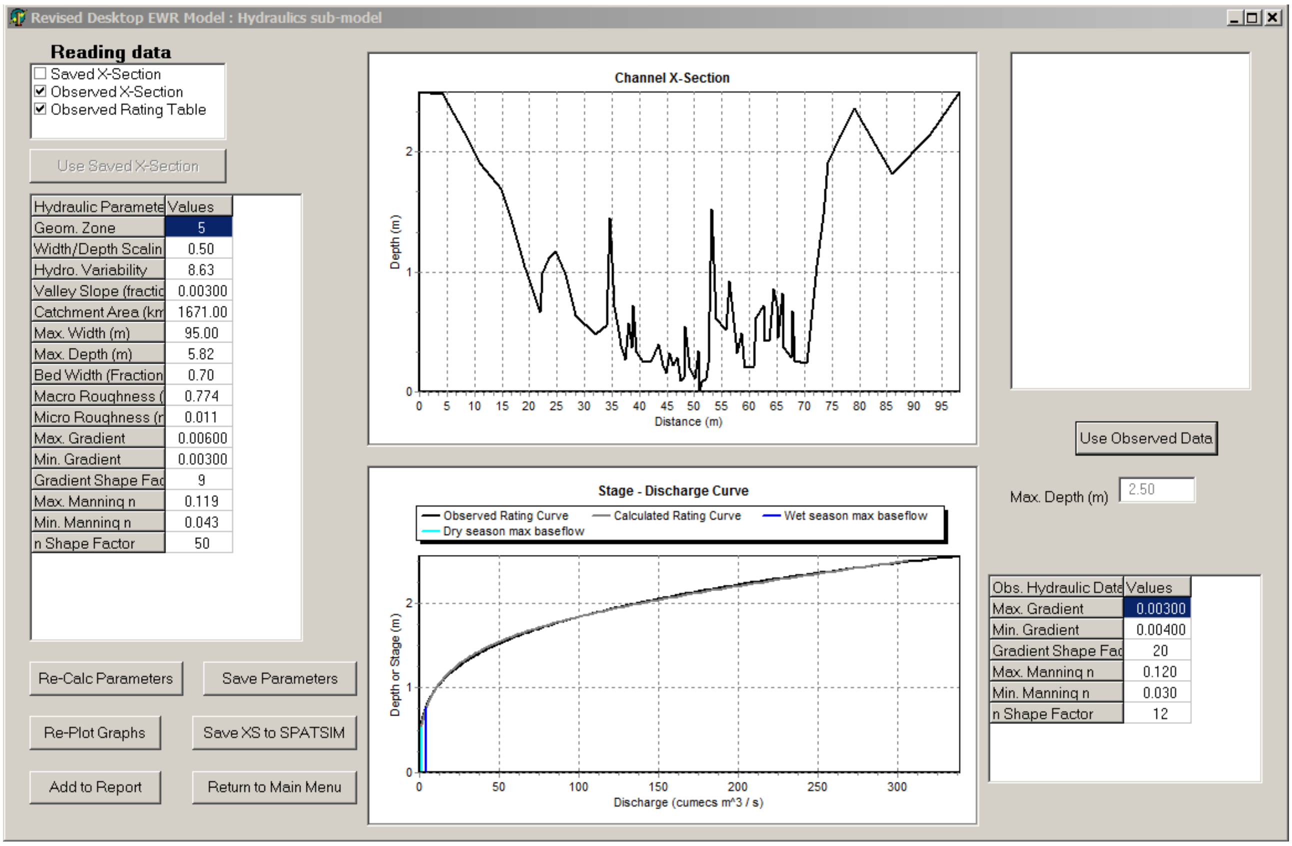


Figure 14.3 The hydraulics sub-model form showing an observed cross-section (top-centre) and rating curve (bottom-centre; black curve), and fitted rating values (bottom-right textbox) that differ from the desktop values (last six values in the left textbox); the calculated rating curve (grey) is aligned with the observed curve.

15 SPECIALIST USE: ECOLOGICAL (LOW FLOWS) SUB-MODEL

15.1 INTRODUCTION

As discussed in Chapters 5 and 10, the low flow ecological component of the revised RDRM model relies on a relationship between flow and ecological habitat stress and it makes use of the estimations of available habitat from the hydraulics model. This component uses three velocity-depth categories, namely *fast-deep* (>0.3 m/s and deeper than 0.3m), *fast-intermediate* (>0.3 m/s and ranging between 0.2m and 0.3m in depth) and *fast-shallow* (>0.3 m/s and ranging in depth between 0.1m and 0.2m in depth) habitats and the flow-stress relationship is based on how the frequencies of the habitats change with changing flow. The model includes parameters that are used to weight the importance of these three fast habitats depending on the presence of different fish species in the reach. In a purely desktop (no specialist input) application of the model, the fish species composition and hence requirement for different velocity-depth categories will be automatically used to calculate the weights. Should the model detect that there is no fish in a reach/site, it will revert to using a default rating to consider the potential presence of flow-dependant macroinvertebrates. When the model is used with the input from an instream-specialist (such as during higher confidence reserve determination studies) it allows the user to change various aspects in an attempt to optimise and improve the results, as well as to verify whether the default model results provide ecologically sound results.

15.2 SUPPORTING AND BACKGROUND INFORMATION

The following background information is available in SPATSIM (NationalV2), is used in the ecological sub-model calculations and can also be used by specialist during the verification process:

- ***Desktop PES*** per SQ reach. This process is described in Section 5.2.3. It is assumed that if a fish specialist will be using the model it will not be at a desktop level and the EcoClassification process for Level III or IV will be followed. The results of this will supersede the PESEIS results.
- ***Fish species*** composition for the SQ reach (or site) (species indicated as abbreviations commonly used by RSA fish specialists, refer to Kleynhans 2003 for full names).
- ***Calculated stress weights*** (stress at no flow and velocity-depth category stresses for wet and dry season).

To obtain the **Fish species present within relevant SQ reach**, the method is as follows (**Figures 15.1** and **15.2**):

- select the ***Rivers SQuat*** feature (1);
- select the "***Fish Species***" attribute (2);
- select the "***show attribute data***" icon on the toolbar (3);
- select the segment of interest (4): a message box will appear (bottom-right) with the river SQ id – select "Add/Edit Arrays" (5);
- a form (**Figure 15.2**) will open containing a table of fish species (abbreviations) for the sub-quaternary reach of concern. This information is extracted from the DWS PES EIES project. The values given for each species indicate the following:
    - 0: This species was present under natural (pre-disturbance) condition but have disappeared as a result of modifications/deterioration.
    - 1: Low probability of presence in reach: The presence of this species in the reach have not been confirmed but based on available information (such as regional distribution, habitat conditions, etc.) there is a possibility that this species may be present.

- 3: Moderate probability of presence in reach. The presence of this species was confirmed historically.
- 5: High/Definite probability of presence in reach. The presence of this species was confirmed recently.
- -9: This species is not expected to be present in reach under natural or present conditions

All fish species rated as 0, 1, 3 and 5 are considered in the calculations for the reach/site, while species rated as -9 are excluded as they are not expected to be present in the reach of concern. This information is used in the model in the determination of the velocity-depth weights (see next section). Should the specialist agree with the default fish species composition of the SQ reach (or site), then exit with “Finished” button. Should the specialist wish to make changes to this list, the following process can be followed (**Figure 15.2**):

- Change the ratings of the relevant species (use only values indicated above, namely 0, 1, 3, 5 and -9).
- Press the “Write to File” button. Select “NO” for request if the array should be inverted, and “YES” to include row and column titles. Then select folder and name to be saved in. This altered species list can also be saved to your SPATSIM database by clicking “Save to DB” (When saving to DB, the information will be changed in Spatsim and when opened again the new values will be given. When only saving to file, and not to DB, the new values will only be saved as text file while the original values will still be available in Spatsim).
- The .txt file saved as part of this process can then be used to re-calculate the weights (this is not automatically done within Spatsim or RDRMv2 and must be done externally by the specialist and then applied within RDRM by input of the new weights in the edit stress weight section). A standalone procedure in MS Excel is being developed for the purpose of recalculating weights using user-defined presence/absence ratings.

To exit this page use the “Finished” button to return to SPATSIM main menu.

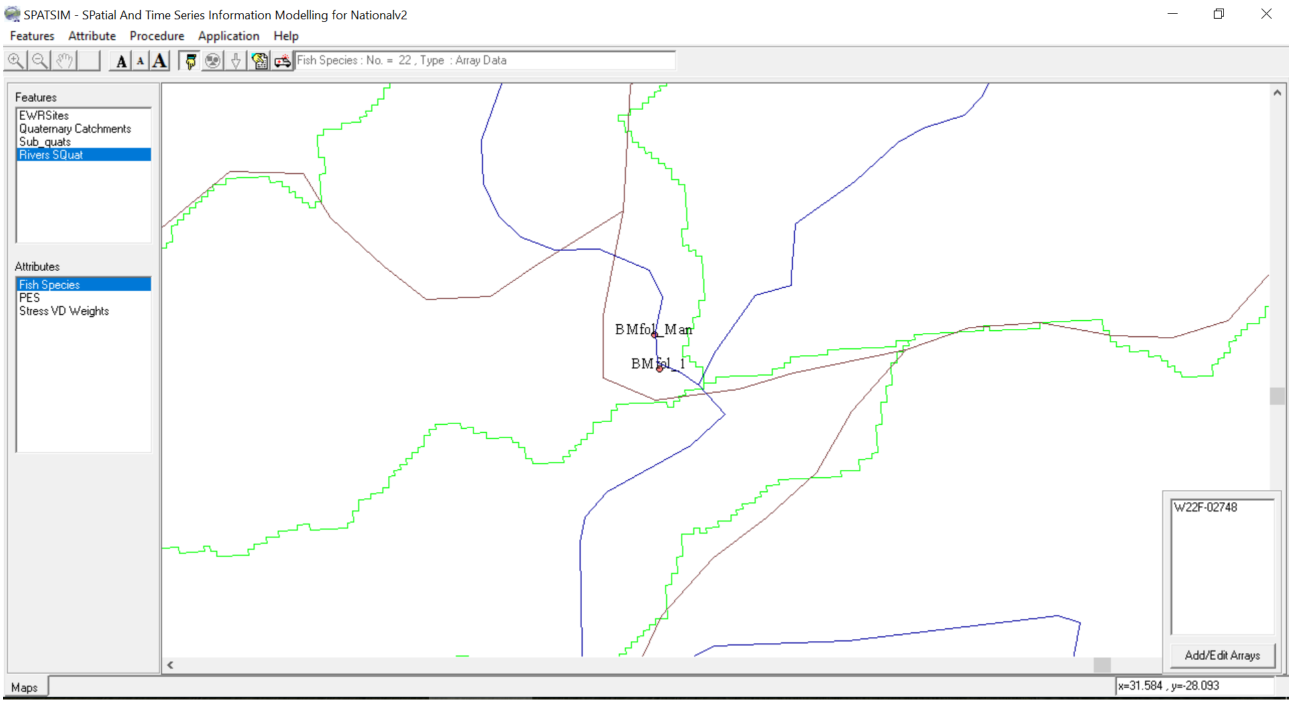


Figure 15.1 Obtaining fish species information

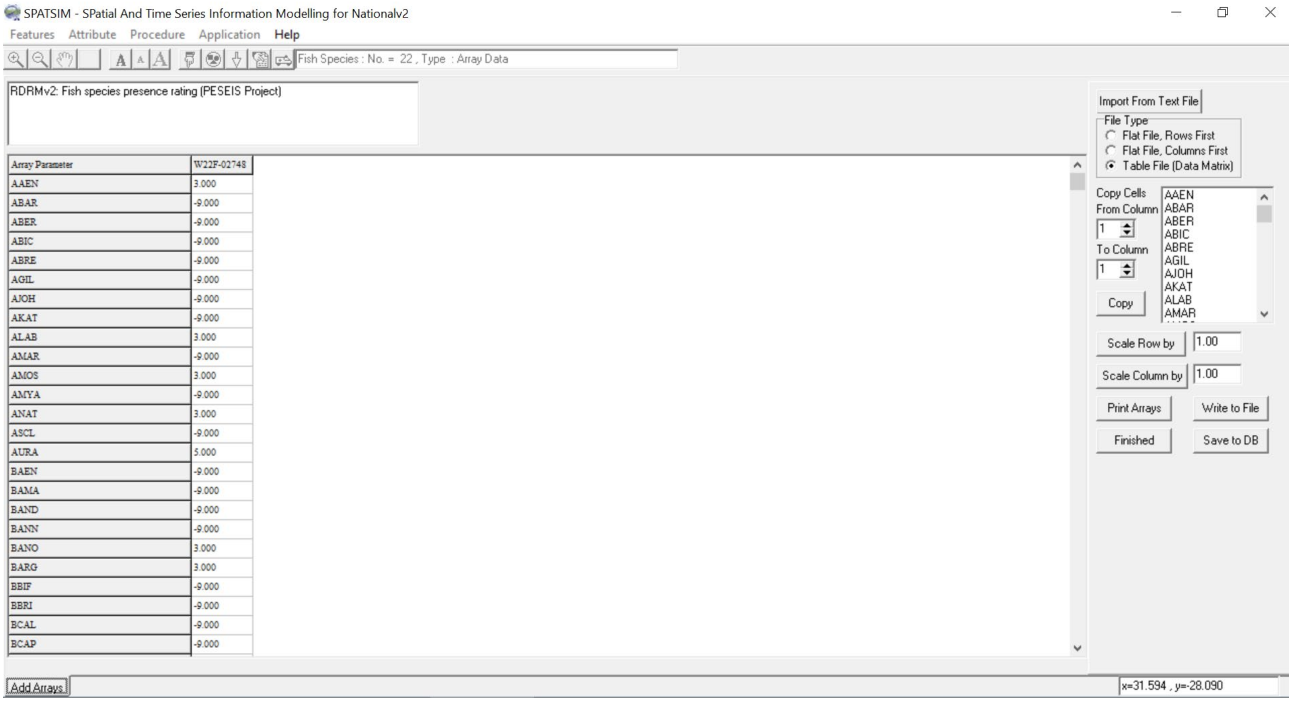


Figure 15.2 Fish species parameter form

To obtain the **stress at no fast flow and relative VD-class weights (for wet and dry season)**, the method is as follows (**Figures 15.3** and **15.4**):

- select the "***Rivers SQuat***" feature (1);
- select the "***Stress VD Weights***" attribute (2);
- select the "***show attribute data***" icon on the toolbar (3);
- select the segment of interest (4): a message box will appear (bottom-right) with the river SQ id – select "***Add/Edit Arrays***" (5);
- a form (**Figure 15.4**) will open containing a table of 8 parameter values required to parameterise the ecological sub-model input data. If these values are all zeros or -9s, then no data are available – i.e. the river segment was not assessed as part of the PESEIS project. Generally, these apply to small ephemeral river systems, impounds, etc. These values must be entered into the parameter array associated with the ecological sub-model of the RDRMv2 (refer to **chapters 5 and 10**). Select "Finished" to return.

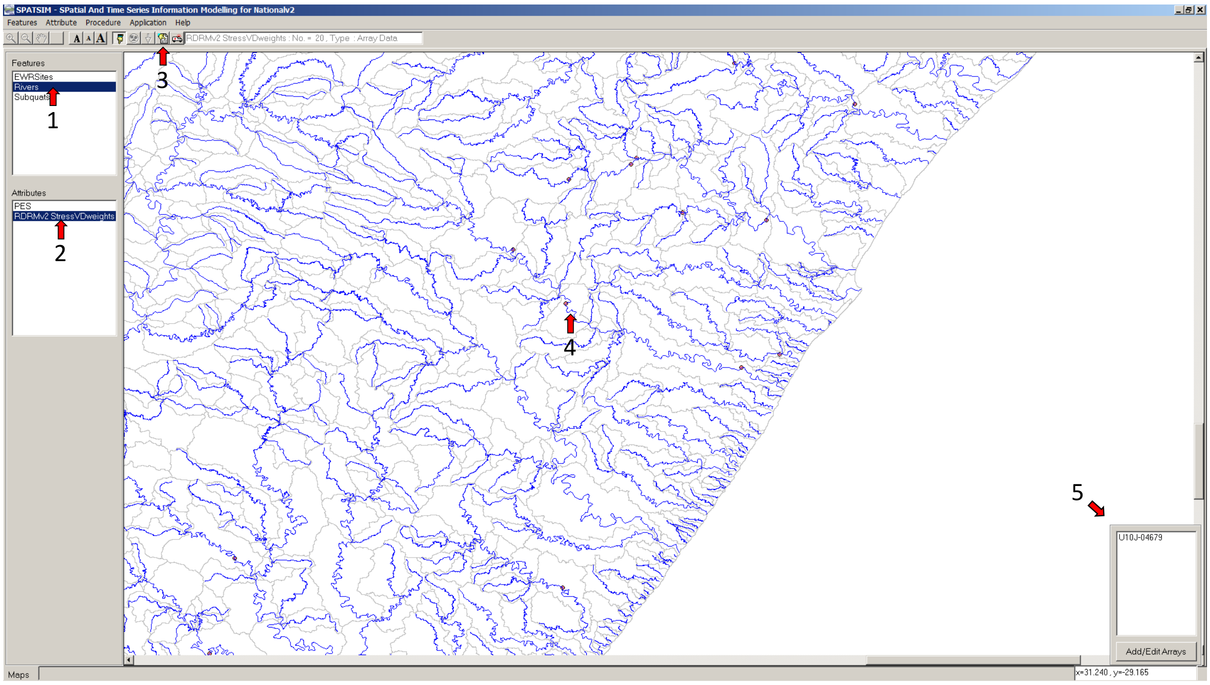


Figure 15.3 Obtaining vd-class weights

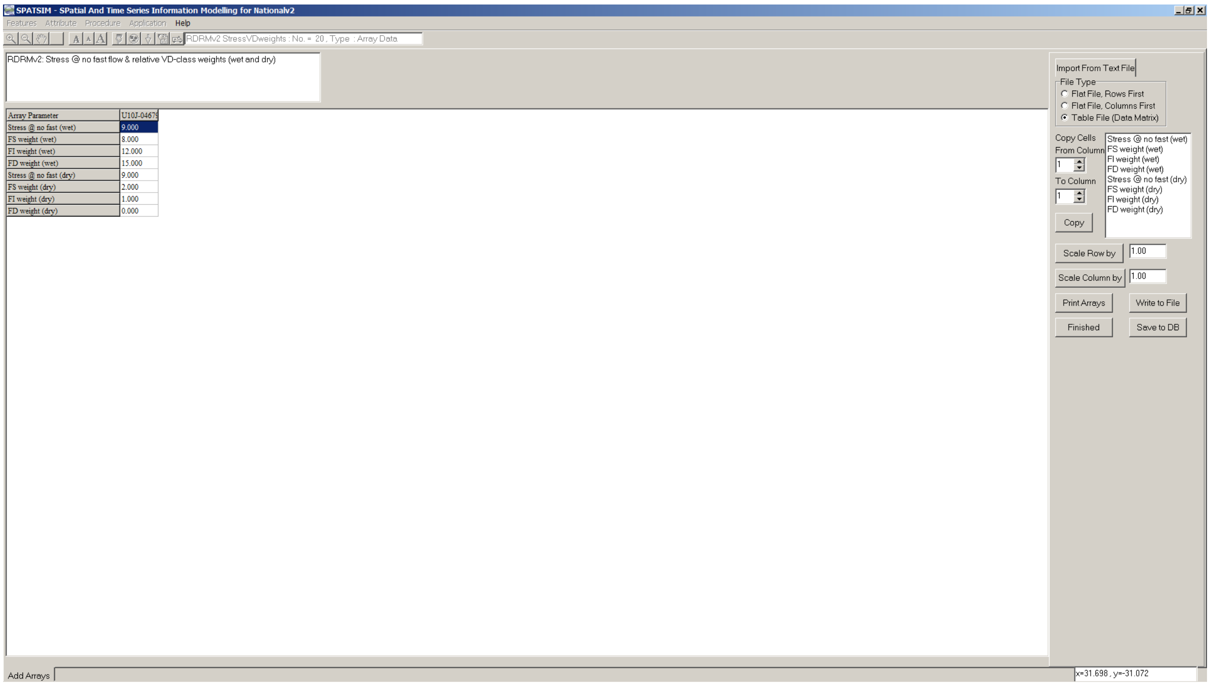


Figure 15.4 VD class weight parameter form

15.3 ADJUSTMENT OF DEFAULT FISH INFORMATION

The actual fish species present along a river reach and their relative requirements or preferences for different (fast) velocity-depth classes were used to compute the relative weights of these classes and the stress at zero fast flow. These are provided in SPATSIM as attributes linked to river sub-quaternary river coverages and need to be transferred to the appropriate parameters in the desktop ecological sub-model. The user (fish specialist) may want to adjust these 'default' values, however, and a standalone computational procedure in a MS Excel has been provided for this purpose. The file contains three worksheets:

- for the site/s under consideration, a list of fish species presence/absence;
- fish preference ratings for different velocity-depth classes, and
- computed weights and stress at zero fast.

The (first two) worksheets have been populated with fish species information used to compute weights for the RDRMv2 but allow for additional species to be added and (weighting) computations to be performed.

15.4 ECOLOGICAL SUB-MODEL (LOW FLOWS)

Within the RDRMv2 ecological sub-model, the time series of natural and present day (if available) flows are processed through the flow-stress relationship to generate time series of ecological habitat stress which are then used to display the natural and present days stress frequency curves for the critical wet and dry season months (**Figure 15.5**). Establishing the ecological Reserve (for low flows) involves identifying appropriate stress curves for each of the ecological categories (A to D), which are then reverse processed through the flow-stress relationships to quantify the Reserve flow time series. It is assumed that the Reserve stress values will be generally higher than the natural stress values (i.e. lower flows), but the upward shifts from natural are controlled by a set of shift parameters for each end of the stress frequency curves (i.e. high stress, low frequency of exceedance and low stress, high frequency of exceedance). These curves are comparable to flow duration curves. The effects of changes in the shift parameter values are difficult to predict and vary with the shape and actual values of minimum and maximum stress. It is therefore extremely difficult for a Desktop user to establish what appropriate shift parameter values to use without guidance from some ecological data on the stress characteristics of the river and its biota.

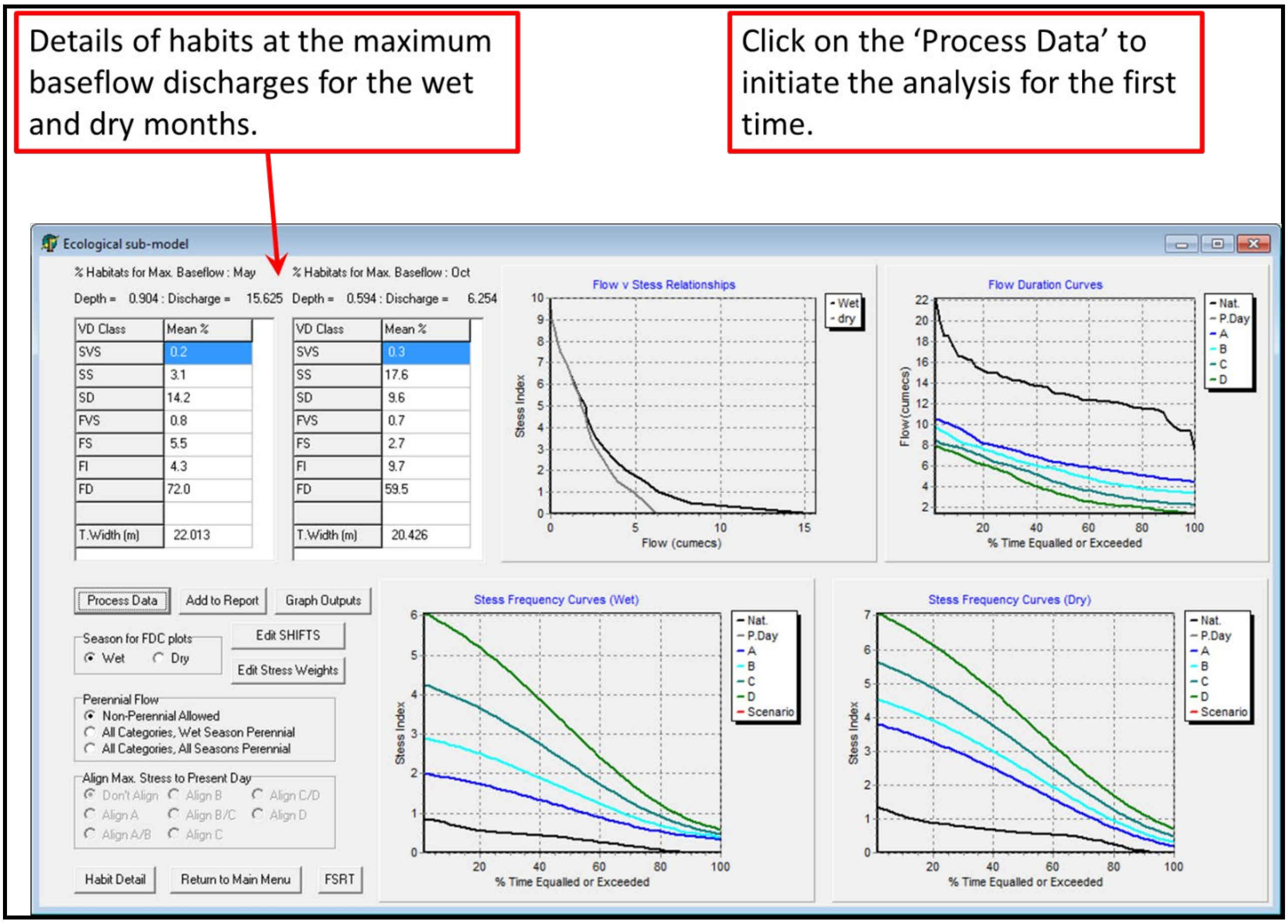


Figure 15.5 The Ecological (low flow) sub-model (main screen)

The following processes/functions may typically be used by specialist to verify/optimise the ecological-sub-model calculations and results:

A) “***Habitat Detail***” button: This function provides the user with detailed habitat graphs of wetted width vs. discharge and % frequency of habitats vs. discharge that can be used in the interpretation and verification of the data (flow stress relationships) (refer to **Figure 15.6**).

B) “***FSRT***” button: The "FSRT" button allows the user to import discharge-stress curves (wet and dry) developed externally to the RDRM by specialists. The information (for the site) is imported from a text file that contains a single column of 18 rows of discharge values: 9 for the wet season followed by 9 for the dry season; the values are the discharges (in m^3/s) corresponding to stress indices of 1 to 9 (a stress index of 0 is the maximum baseflow, and a stress index of 10 corresponds to no surface flow).

C) Changing stress weight relationships (“***Edit Stress Weights***” button)

D) Changing stress shifts for ecological categories by

   a. Editing the category shifts (“***Edit SHIFTS***” button)

   b. Allowing perenniality or non-perenniality (Perennial flow section). Currently not active in model.

   c. Aligning maximum stress to present day (***Align Max. Stress to Present Day***” section.

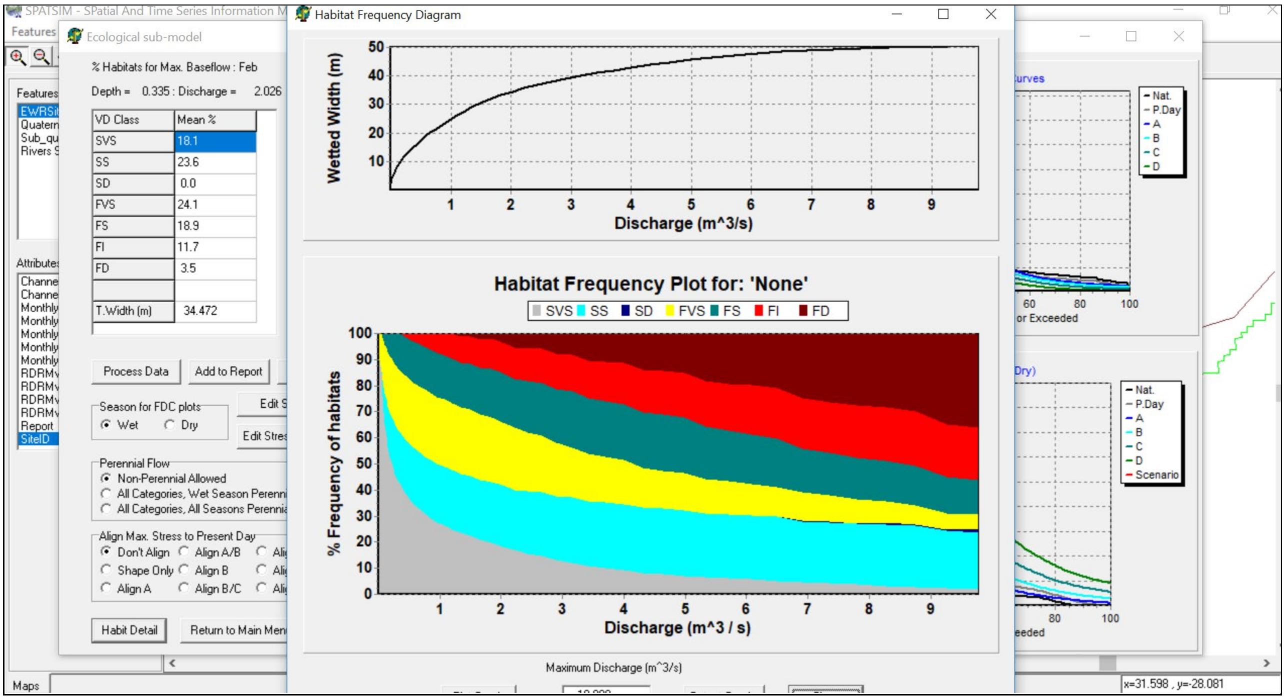


Figure 15.6 Example of habitat detail graphs provided in ecological sub-model.

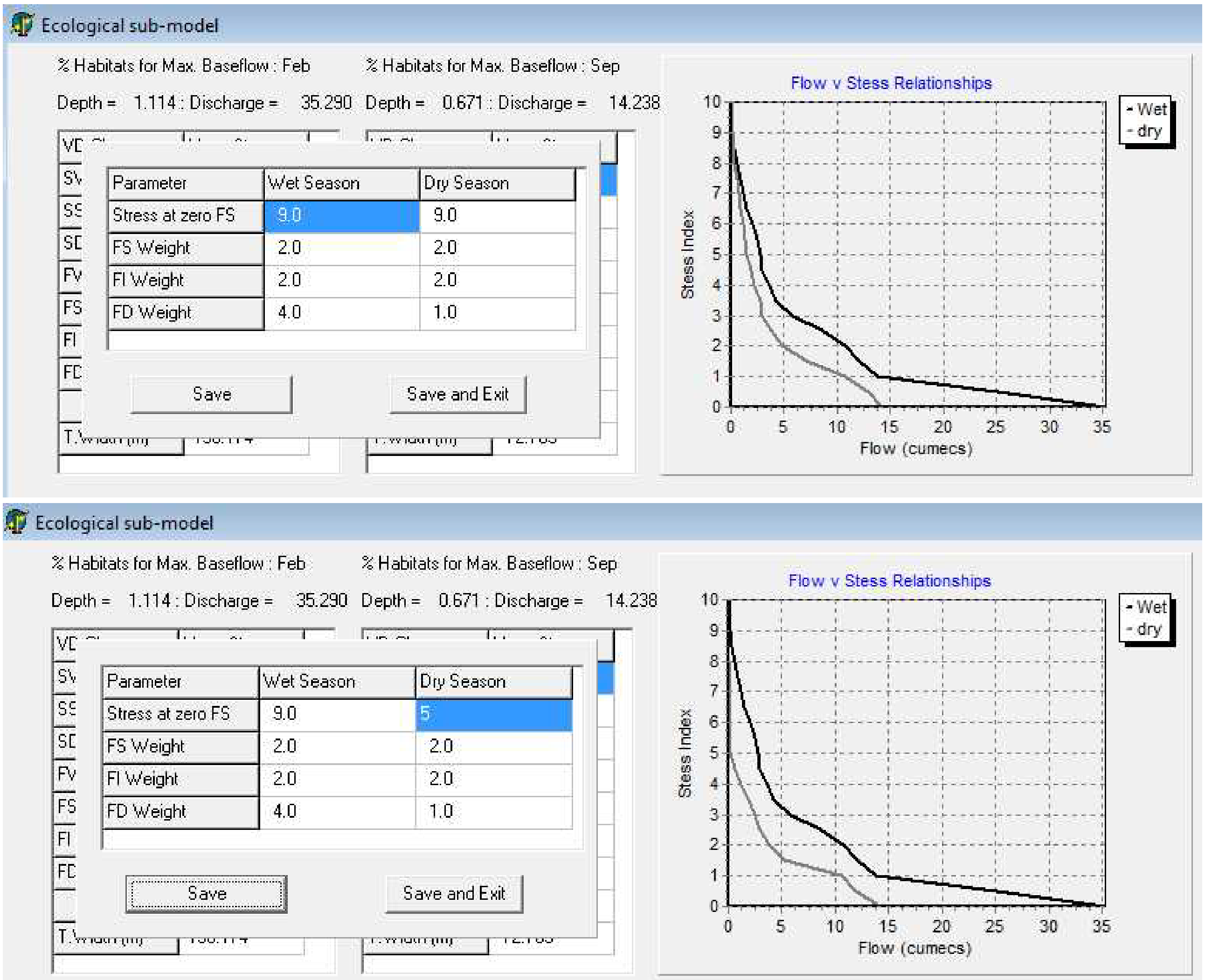
<u>Changing stress weight relationships (“Edit Stress Weights” button) (Figure 15.9)</u>

As discussed in detail in Chapter 5 and 10, the actual fish species present in a river reach and their relative requirement or preference for a specific fast velocity depth category was used to determine the stress expected at zero flow, and the relative importance (weight) of the fast-deep, fast-intermediate and fast-shallow habitats in the wet and dry season. The desktop user will transfer these results (weights) SPATSIM to the ecological sub-model. An aquatic (instream) specialist may however want to adjust these weights under some conditions, such as:

- If the actual fish assemblage at the site (based on all available information, including surveys, etc.) is different from the fish assemblage used (desktop PESEIS project). In such cases the importance (weight) of the three fast velocity-depth categories used, may require changes.

- If macroinvertebrate (or any other aquatic biota) requirements for the site is available and it requires a change in the stress weightings. An example of such a scenario would be when only limnophilic fish species are present, but various rheophilic invertebrate taxa are present, it will require an increase in the stress as zero FS and potentially also the three velocity-depth categories. (The expected macroinvertebrate taxa per sub-quaternary reach is available as part of the DWS PESEIS project results and could also potentially in future be included in the Spatsim database for easy reference).
- The stress graph appears unrealistic when considering the specific biota and habitat composition under different flows.

The '***Stress at zero FS'*** effects the high stress end of the curve mostly. The effects of changing the weights is highly dependent upon the amount of different fast habitats and how they disappear as the discharge decreases and it will vary with every site (**Figure 15.7**).



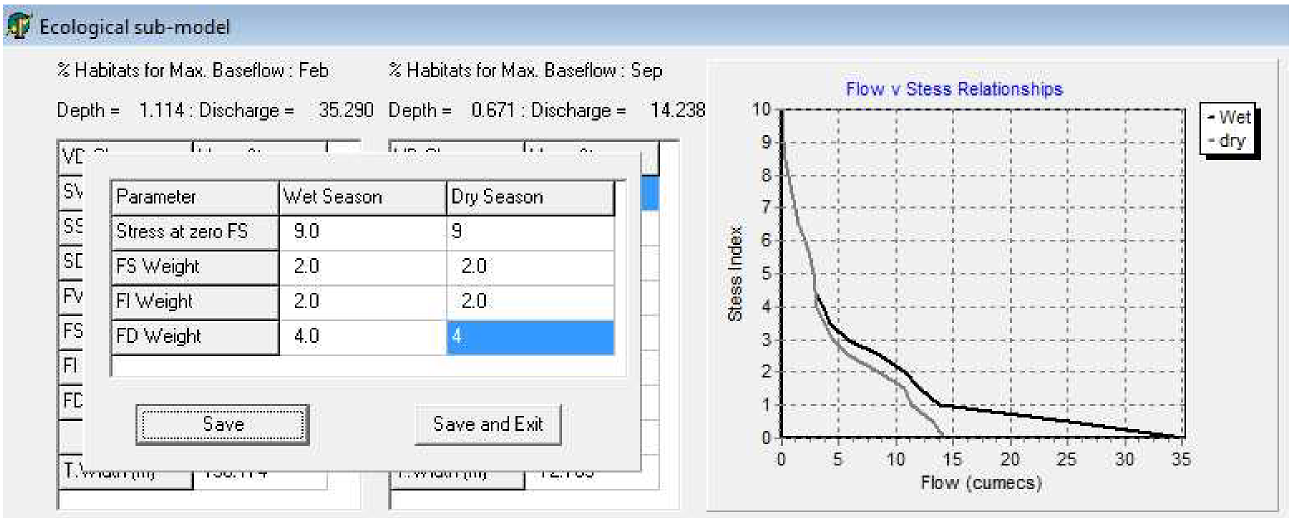


Figure 15.7 Changing stress weights in the ecological sub-model.

__Changing stress shifts for ecological categories (Figure 15.10)__

The shifts (for the full range of ecological protection categories) are now absolute values of stress in the revised RDRMv2 (previously they were relative shifts). The default values are based on some rules that you first fix the D category line, after which the other lines are spaced between the D and Natural (A) (**Figure 15.8**). The shift parameter values are simply the positions of the end points of the ecological category stress frequency curves and changing a value will shift the high or low stress end of the curve. This should only be done if site-specific ecological information (typically based on the hydraulic habitat data) is available from an ecological specialist.

NOTE:

The default shift parameter values are re-calculated if the channel hydraulics are changed (e.g. if you re-run the hydraulics sub-model using randomly generated X-sections). When the Ecology sub-model starts the user is given the option to reset any saved shift values to the calculated default values. If this option is not selected, it may still be necessary to adjust the user-determined shifts to ensure that they are compatible with the current hydraulic data and the current values of the stress weights.

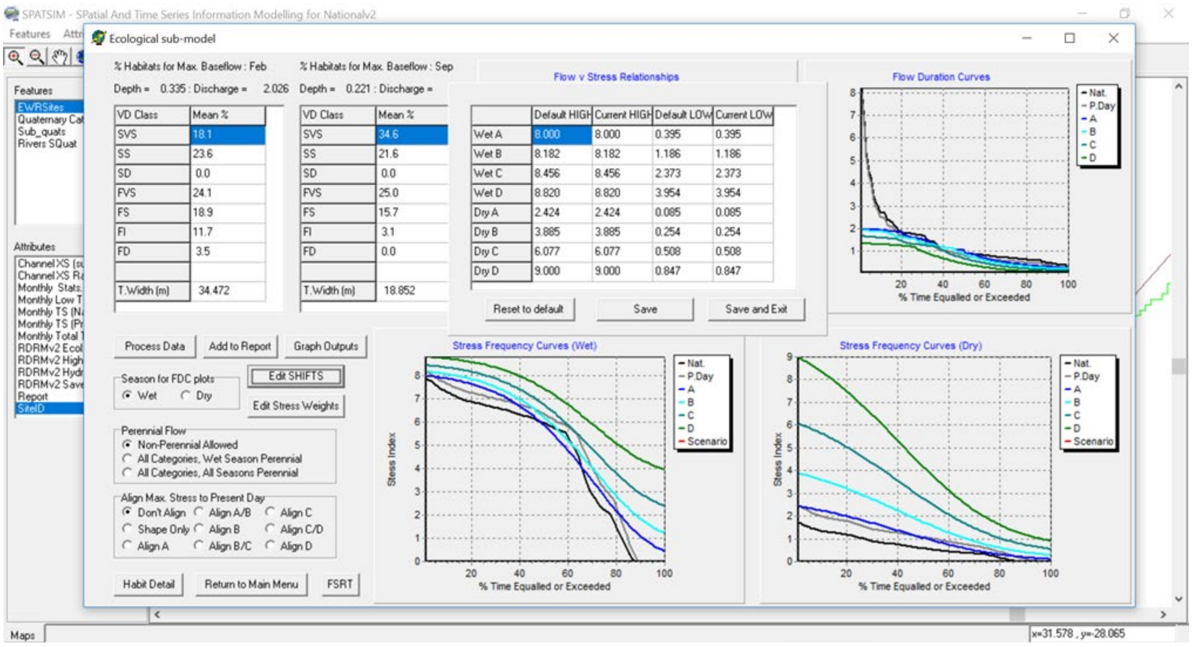


Figure 15.8 Changing category shifts in the ecological sub-model.

Aligning maximum stress to present day

There are two main options for aligning the shape of the stress frequency curves to the Present Day condition.

- The first is to use the shape of the Present Day curve only, but leave the end points associated with Natural (Shape Only).
- The second is to align a specific Ecological Category. The maximum stress (for that category) is set to be the same value as the present day maximum stress and the other category maximum stress values calculated on the basis of standard separation distances. The low stress for a D category is set (by default) to 0.5 * the maximum stress. The shape of the category curves also approximates the shape of the present day curve.

Figure 15.9 illustrates the situation where no alignment using the default shift values takes place. Note that the high stress end of the D line is based on the loss of all fast habitats, while the low stress D line is set at 0.5 * the maximum natural stress.

Figure 15.10 illustrates the effects of aligning the B category to the present day stress frequency curve. The high stress for B is set at the maximum present day stress and the low stress for the D category set at 0.5 * the maximum present day stress.

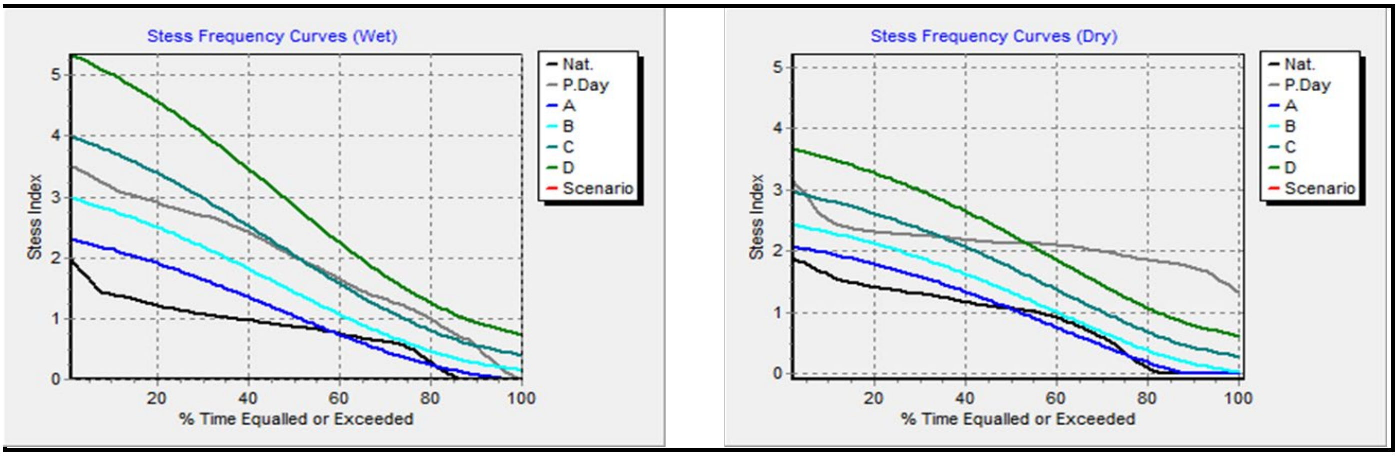


Figure 15.9 The ecological (low flows) sub-model (aligning to present day for a specific category

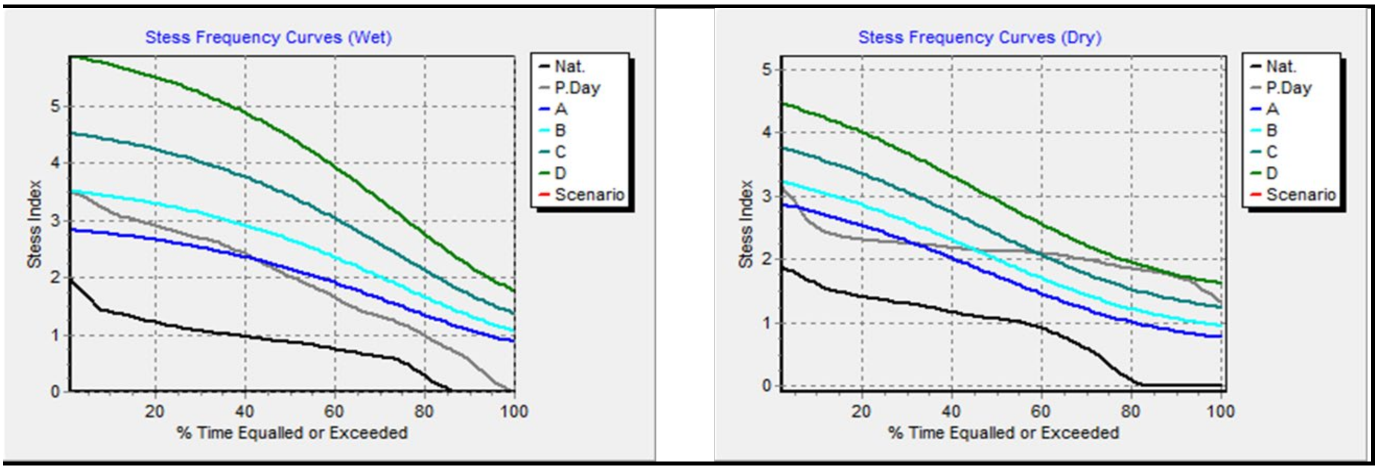


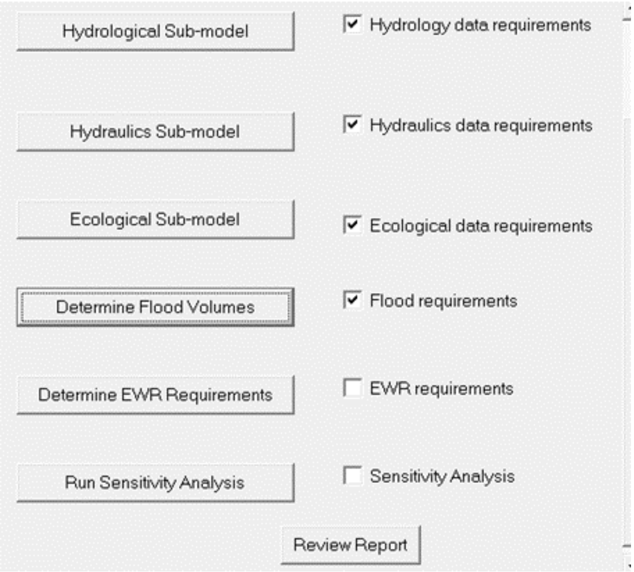
Figure 15.10 The ecological (low flows) sub-model (aligning the B category to the Present Day stress frequency curve).

16 SPECIALIST USE: HIGH FLOW SUB-MODEL

The high flows are now based on a set of defined high flow event hydrographs. The default peaks are based on empirical equations using a combination of the maximum wet season baseflow, the bankfull discharge and the coeff. of variation of the highest flow month (see the Hydrology component). The time to peak and total duration are based on statistical relationships with catchment area, shape and slope. The default number of events and their expected frequency of occurrence are also preset.

The empirical equations for the peaks (QP) of the different flood classes are given below (MBF = maximum wet season baseflow, BFQ = bankfull discharge, CV = coefficient of variation of monthly flows of the wettest month) and are based on an analysis of previous EWR determinations in South Africa:

Class 1: $QP1 = 2.6 * MBF^{0.736}$
Class 2: $QP2 = 3.44 * MBF^{0.685} + QP1$
Class 3 (annual event): $QP2 = 4.3 * MBF^{0.6} + 0.006 * (BFQ / (1+CV))^{1.29} + QP2$
Class 4 (1:2 yr event): $QP3 = 1.47 * (BFQ / (1+CV))^{0.62} + QP3$
Class 5 (1:5 yr event): $QP4 = 2.5 * (BFQ / (1+CV))^{0.74} + QP4$



Click on the “Determine Flood Volumes” button. This will open the High Flow sub-model. The layout is shown in **Figure 16.1**. The high flows that will be listed are based on empirical equations using a combination of the maximum wet season baseflow, the bankfull discharge and the coefficient of variation of the highest flow month (see the Hydrology component). The specialist will want to update and override these based on the results of the specialist study. The time to peak and total duration are based on statistical relationships with catchment area, catchment shape and river slope. The specialist will adjust these, if needed, to represent the real situation. The default number of events and their expected frequency of occurrence are also preset and will also be updated by the specialist.

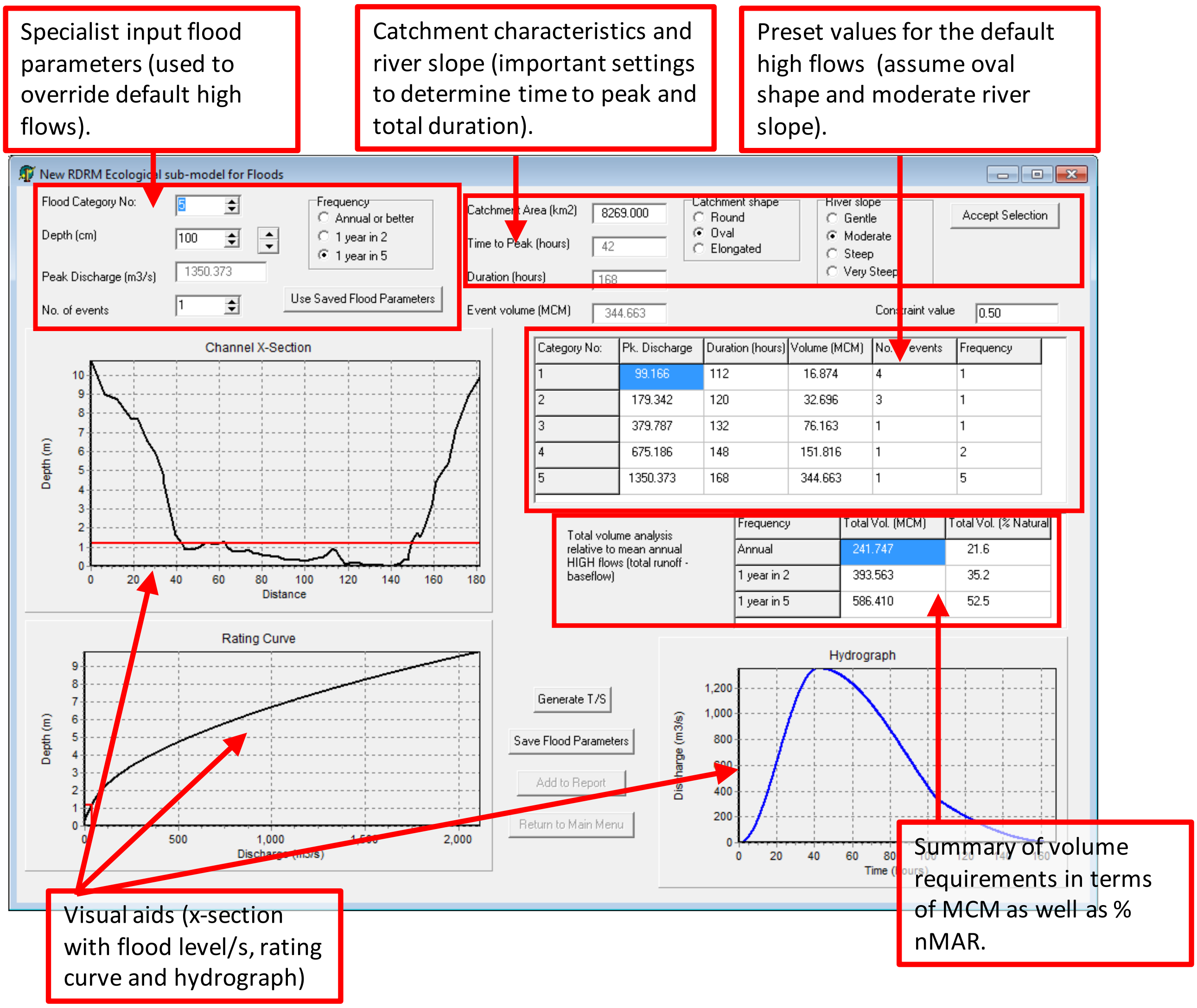


Figure 16.1 Ecology (High Flows) sub-model layout.

16.1 ADJUSTING CATCHMENT CHARACTERISTICS

The first task of the specialist is to adjust the required catchment characteristics so that they represent the system and site being assessed (Follow the steps in **Figure 16.2**). The three characteristics used are catchment area, shape and slope. Please note that this is not the river slope of the site, but the slope of the catchment as denoted by the full catchment length of river.

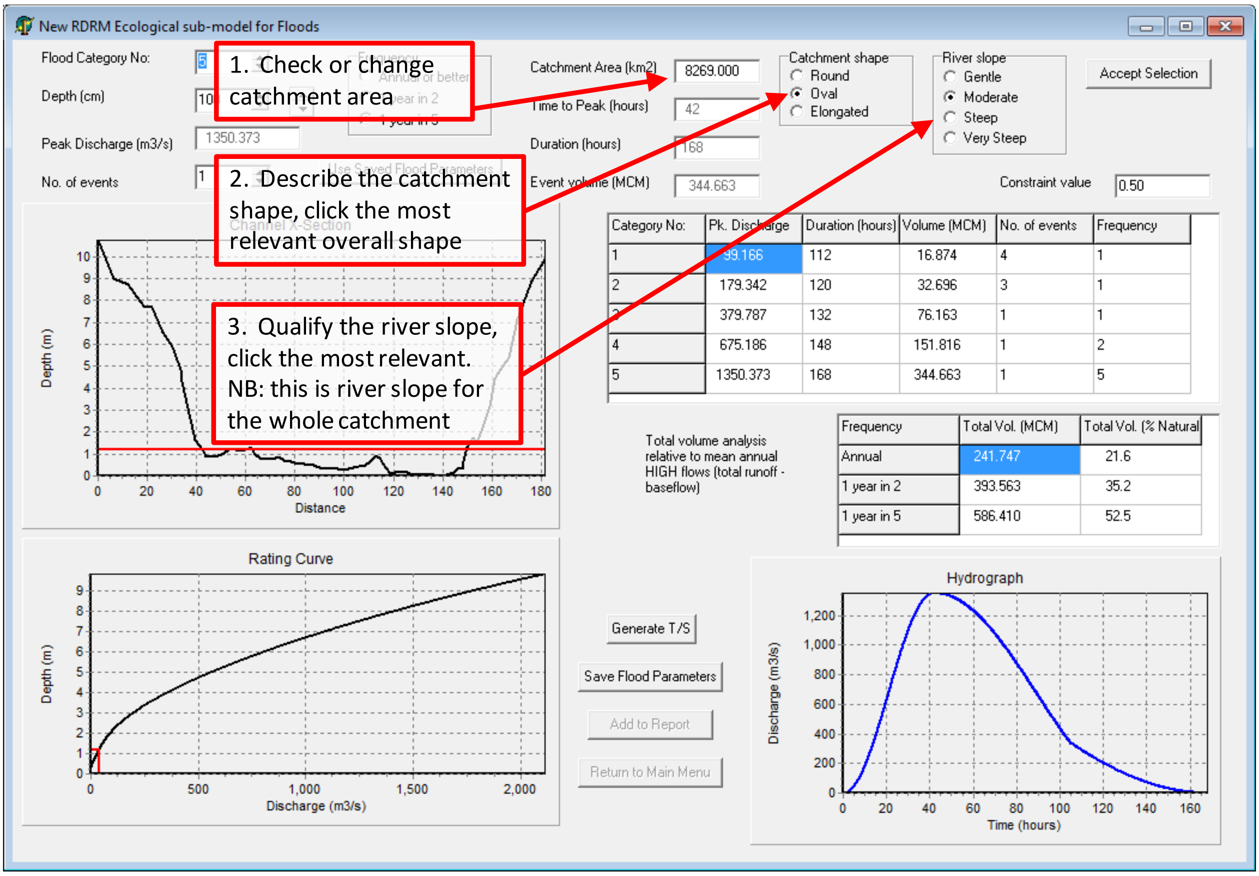


Figure 16.2 Adjusting catchment characteristics.

16.2 SETTING FLOOD PARAMETERS

This is the most important task for the specialist and requires the capturing of actual flood requirements into the model, as determined in the specialist field studies. The model caters for 5 flood categories, each of which needs to be set by the specialist in terms of frequency and magnitude. **Figure 16.3** outlines the process to follow. Please take note of the following: it is best to start with flood category 1, which is always the smallest and most frequent flood, and work towards category 5 which is always the largest and least frequent (generally occurs once every 5 years).

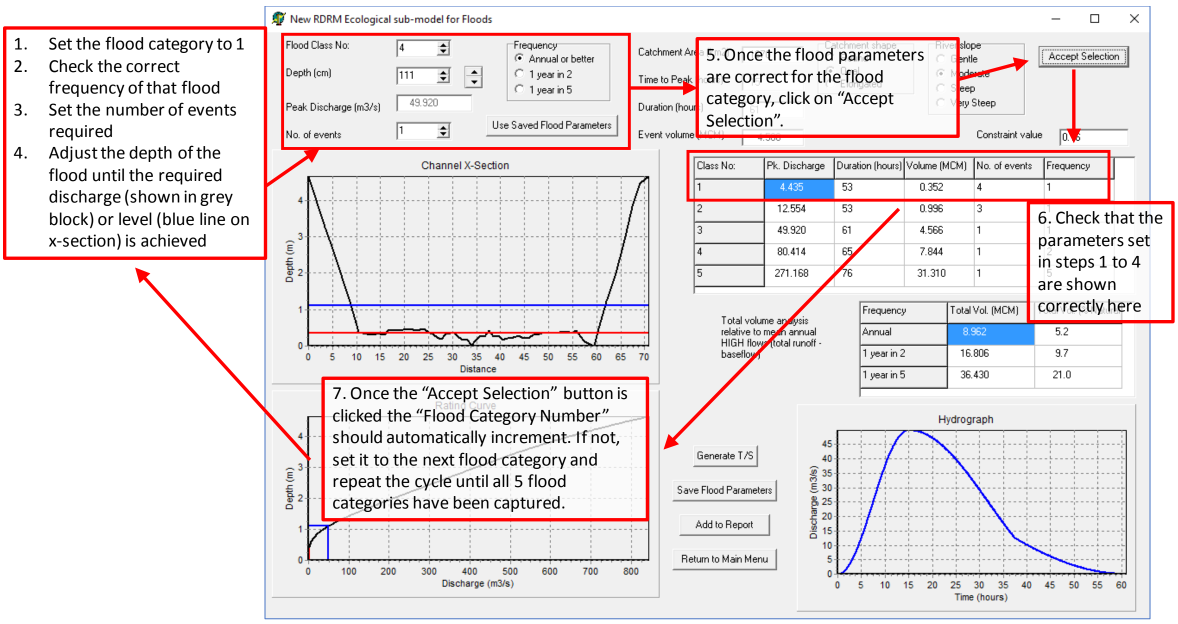


Figure 16.3 Overriding default flood parameters.

16.3 OVERRIDING DEFAULT FLOOD DATA

Once the flood parameters have been set to represent the actual requirements at the site, these flood parameters are then used to generate the high flow time series, which will contribute to the overall EWR. The final steps required in the HIGH FLOW sub-model are shown in **Figure 16.4**. Please note that before one can save the new flood parameters, the optional data input of the RDRM run (labelled “7. Saved Flood Parameters”) must be linked to the High Flow attribute data (see Table 6.1).

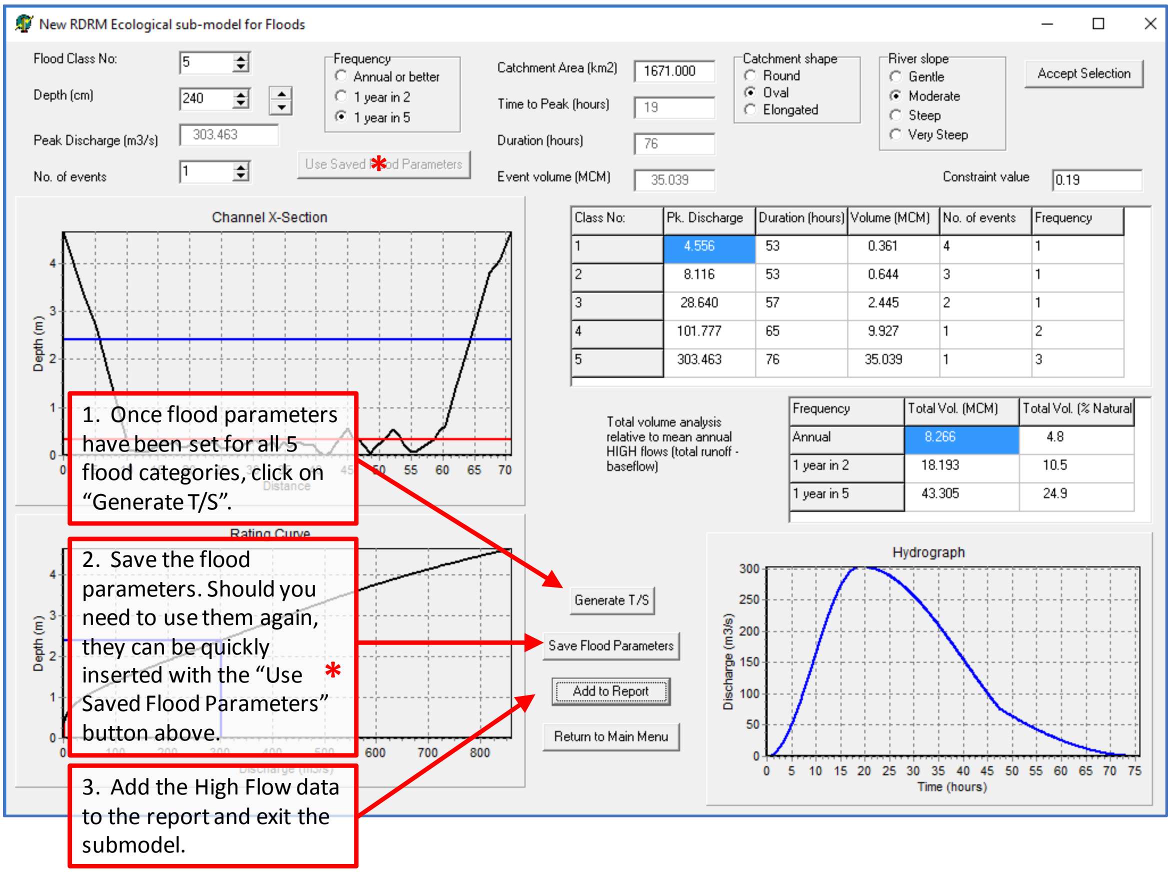


Figure 16.4 Overriding default flood parameters with specialist’s data.

17 REFERENCES

Department of Water and Sanitation (DWS). 2014. A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub-Quaternary Reaches for Secondary Catchments in South Africa. Compiled by RQIS-RDM: https://www.dwa.gov.za /iwqs/rhp/eco/peseismodel.as