## 4. AVAILABILITY OF SUITABLE FLOW DATA

In an ideal situation, a long representative time series of daily flow data should be available from which any indices of variability could be generated and used for comparison with the flow observed at the time of a biomonitoring sample site visit. However, if biomonitoring sites were restricted to locations where such flow data were already available there would be very few sites and they would probably be far from ideal from a biological sampling point of view. It is therefore necessary to look for alternative approaches to estimating the required data and there are several possibilities.

The first distinction can be made between ***generating a time series*** for the site of interest and ***relying upon regional relationships*** between readily obtainable information (indices of climate, physiography, soils, vegetation, geology, etc.) and the required hydrological indices. The latter approach has been used extensively in Australia but less so in South Africa. Unfortunately, to establish the relationships requires a great deal of initial analysis and even then are very approximate and rely on the initial database being spatially representative - something that is always difficult to demonstrate. The alternative of generating a site specific time series is far more flexible as a wide range of analyses can be performed on the data at any stage and the initial data preparation is not specific to a certain set of indices or analysis methods. There are also established software packages available in South Africa for carrying out the required analyses and generating the type of variability indices referred to above.

***It is therefore recommended that the approach for quantifying the hydrological indices should be based upon one or more methods of generating representative time series of flow data.***

There are two separate issues associated with the acquisition of the necessary flow data :

- ***Historical flow data*** : The first objective is to generate a relatively long representative time series to establish the regime characteristics against which on-going observations and measurements can be compared. It may be desirable that either a natural series or one incorporating development impacts be generated, or both.

- ***Real-time flow data*** : The second objective is to be able to determine the patterns of flow that have occurred between sampling visits and at the time of sampling. Although these data are referred to as ‘real-time’, in practice they might not be always available at the time of sampling and there may be a data acquisition delay of several months.

There are a number of different approaches that could be adopted for generating a time series of representative flow data (for both historical and real-time requirements) and the choice depends upon the proximity of available flow data, the extent to which upstream developments have impacted on the natural flow regime and the specialist hydrological expertise available. Time constraints are not considered to be very important as it is assumed that the biomonitoring sampling will be a long term programme. It is also worth noting that the methods used for generating the historical data do not necessarily have to be the same as those used for the real-time data.

## 4.1 Rainfall-runoff modelling

Rainfall-runoff models rely upon a mathematical representation of catchment hydrological processes to convert time series inputs of rainfall (and frequently evaporation demand) to time series outputs of streamflow. Different models operate with different time steps, but the most common distinction is between those that generate monthly volumes of streamflow and those that are able to generate mean flow rate on a daily basis.

There are a number of models available in South Africa that could be used to generate daily flow time series from more readily available rainfall data. Most of them require specialist hydrological modeller's to set up, calibrate and ensure that the results are representative. They have the advantage of being reasonably flexible in terms of being able to predict flow regimes under differing degrees of catchment development and therefore could be useful in catchments which are undergoing rapid changes. The main disadvantage is the fact they are data 'hungry' and require quite extensive resources in terms of expertise, time and information to establish and generate reliable results.

Generation of real time data would involve obtaining up-to-date rainfall data and extending the period of simulation using the calibrated model parameters. Using the modelling approach it would normally be necessary to assess the actual flow conditions at the site during sampling which would require either time consuming flow measurement during each visit (using a current meter and surveyed cross-section), or a calibrated rating curve (depth-flow relationship) at a hydraulic cross-section and a flow depth gauge plate. These observations could then be used as a check against the modelled flows and as the database of spot samples of flow rates is extended, it will be advisable to carry out a re-calibration of the rainfall-runoff model.

## 4.2 Disaggregation of existing monthly time series

The WR90 publications (Surface Water Resources of South Africa 1990) contain 70 year monthly time series of naturalised flow for every quaternary catchment in South Africa. Such a source could be used with a regionalised procedure for monthly disaggregation to generate a daily time series (see some of the techniques referred to in Smakhtin (2000). Dissagregation procedures are available but have not been extensively tested. They essentially rely upon finding regional relationships between the characteristics of monthly and daily time series, frequently by relating the characteristics of the daily and monthly flow duration curves. While this approach is initially very attractive, because of the nationwide coverage (at quaternary catchment scale) provided by the WR90 data, it is important to ensure that these data are satisfactorily representative of the flow regime of the river being monitored. It has already become apparent that in some catchments, for example, the WR90 winter low flows are over-estimated. The main point is that these data (which are mostly the result of a regional model parameter extrapolation exercise and are not always verified against real conditions) should not be blindly accepted, just because they are easily accessible.

The comments under rainfall-runoff modelling about the need to measure flow during the site visit, or hydraulically calibrate the site and monitor water depth, apply to this approach as well. Generating real-time data is not readily possible using this approach and estimating high-flow and flood conditions cannot be considered very reliable.

### 4.3 Extrapolation from observed flow data in the vicinity

This approach involves selecting existing flow gauging sites (operated by DWAF) where the flow time series have basically the same characteristics, in terms of catchment response, as the biomonitoring site and carrying out a spatial extrapolation procedure. Such procedures have been developed and have been demonstrated to be quite valuable in several regions of southern Africa (Hughes and Smakhtin, 1996). Problems arise when the extent of upstream development is different in the observed data (sources) catchment(s) compared with the catchment above the site of interest (destination), but techniques to address such issues are being developed. The methods work reasonably well with low flows, but are less reliable for peak flows during individual events. This is largely because patterns of baseflow response are much more regionally consistent than flood events caused by spatially variable rain storm events. It will be necessary to employ the expertise of a hydrologist in the selection of suitable gauged sites to use to carry out the extrapolation.

These techniques can be used to generate the historical time series as well as the real-time data, as long as the source flow gauges remain operational. They also avoid the necessity for flow measurements (or stage readings) during site visits (although this is still advisable to provide an accuracy check), but rely on being able to get near real-time data from the key gauging station(s).

### 4.4 Simple extrapolation from rainfall data

A rainfall-runoff model is a set of complex transfer functions that allow streamflow data to be estimated from rainfall data. Some research work has recently been undertaken to develop more simple transfer functions that are generally applicable but easier to set up and apply than rainfall-runoff models (Smakhtin, 2000). The prospects look quite promising but there is still a lack of clarity about how easy it will be to establish sets of model parameters for a large number of sites in different climatic regions. Accounting for upstream developments would be similar to the approaches used in rainfall-runoff models and generating real time series would involve the collection of real time rainfall data from a set of key gauges.

### 4.5 Summary of recommended approaches

The last two methods (4.3 and 4.4) seem to offer the most pragmatic solution to the problem of being able to generate sufficiently representative historical flow time series data and continue to generate data during the monitoring period. It will usually be advisable to establish what the flow really is at the site at the time of monitoring to ensure that the real-time estimations are within acceptable margins of error. The only really suitable approach is to hydraulically calibrate the channel cross-section through an initial survey, a number of flow gaugings carried out (to develop a stage-discharge rating curve for the biomonitoring site) until a range of flow conditions has been covered and a stage plate installed for long term monitoring of flow depth (converted to flow rates using the stage-discharge curve). A hydraulic model can be used to extrapolate from a limited number of gauging observations to provide an initial estimate of the full rating curve.

As already mentioned, the most appropriate approach will depend upon the characteristics of the site, the spatial variability of regime characteristics in the region and the availability of flow data within the vicinity. ***The decision making process about the most reliable and efficient method to use will be beyond the expertise of most biomonitoring specialists and a hydrological specialist will normally have to be consulted to select and establish the most appropriate method for a specific site and train the biomonitoring team in its application.***

In terms of the real-time collection of flow data during sampling visits, it will be important to ensure that a suitable hydraulic cross-section is selected and that the stage-discharge rating curve is estimated with appropriate accuracy. The advice of a hydraulic specialist will normally be required.