The Biological and Chemical Database

User Manual

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1. INTRODUCTION

The compilation and development of the biological and chemical database has taken place over the last five years. Initially, the intention was to utilise the data to assist in the construction of rating curves for use by the Department of Water Affairs & Forestry (DWAF). Subsequently this objective became inappropriate and it became clear that the development of a database derived from biological (macroinvertebrate) data and which included relevant chemical and physical parameters of the associated water body, would provide useful information for ascertaining the characteristics of waterbodies with respect to both the biology and water chemistry. Subsequent advances in associated projects and the initiation of the national biomonitoring programme for riverine ecosystems reinforced the potential usefulness of such a database, and led to the inclusion of a number of other features such as spatial scales (e.g. bioregions, water quality management regions, subregions etc.) and data related to SASS (South African Scoring System). One of the most important aspects of the biological and chemical database (BCD) is that it enables the linking of biological and chemical variables on both spatial (data collected from the same place) and temporal (data collected at the same time) planes.

1.1 Sources of data

The database has been constructed using data extracted from much of the available literature and unpublished reports pertaining to South African rivers, in which biological and chemical data have been collected concurrently. Most of the biological data that are available relate to the benthic invertebrate fauna, although some work has been done on fish taxa. This bias is probably a result of the early recognition of the fact that benthic fauna provide an easy and fairly reliable way of assessing pollution (Chutter 1972). Records of the invertebrate riverine fauna thus form the biological component of this database. These data include those from intensive studies of individual systems (Harrison 1958, Chutter 1963, 1967), extensive one-off surveys of regions (Kemp *et. al* 1976), *ad hoc* surveys (Harrison and Agnew 1960, 1962) and impact assessment reports (O'Keeffe 1987, 1989). Thus far forty-three studies have contributed to the biological records of the database, of which forty had associated chemical data. Updating of the records from fresh sources will be an ongoing exercise (funding permitting). Details of the history and source information for the database have been previously documented (Dallas *et al.* 1994).

The chemical data used have been extracted from the same literature sources as the biological data, but vary between studies in terms of the number of variables analyzed. The main criteria for the inclusion of chemical data have been the exact or approximate coincidence of these measurements with those of the relevant invertebrate biological details. A complete list of the study references used is provided in Appendix F. Appendix G describes each of these studies in detail, listing which records were extracted and what if any adjustments were made to allow compatibility with other records. A total of 140 000 biological records have been entered into the database thus far, and most of these are accompanied by records of chemical conditions (between 1 and 48 chemical variables covered in each case) in the river at the time of sampling. The time spanned by the records dates from 1951 (Berg River; Harrison and Elsworth 1958) to the present, and, in the case of some rivers (e.g. Berg River, W. Cape), records are available from several consecutive studies, which provide a historical trace of both biological and chemical conditions.

This manual describes the structure of the database, both in terms of the spatial frameworks incorporated and the type and quality of data. It outlines the Query Centre designed to facilitate querying by users with a basic knowledge of Microsoft Access and Excel. Three pre-defined query frameworks enable querying of biological data, chemical data, or chemical parameters linked to biological ones. Technical information of the computer hardware and software requirements for running the biological and chemical database is detailed in section 4. This manual also describes the potential uses of the database and, more importantly, expands on the limits of its applicability. There is always a danger that a large store of data such as this may exude an air of reliability by virtue of its size alone. It is important to understand and be aware of the problems involved in amalgamating records from different sources, relating to data gathered by different authors, at different levels of intensity, and for different purposes.

2. STRUCTURE OF THE DATABASE

The structure of the database is described in the sequence in which a user is likely to apply it. All viewing, editing and querying are accessed via the **Control Centre**. Your options are:

	Button	**Function / action**
1	Sites	to display all sites
2	Biological and Chemical Data	data entry/viewing of site visits
3	Taxonomy	taxa used in the database
4	References	Study References (Author, Year, Title, Journal, etc.) on which data is based
5	Picklist Options	to change various options (entries in drop-down lists)
6	Query Centre	to query the database
7	Stop	to exit the database

2.1 Sites

Existing data on sites incorporated in the database are viewed via this button. It is divided into two tables, one which provides an overview of sites (Summary Site Table) and one which gives details of each site (Detailed Site Summary). Associated with each site is information on the spatial location of the site. To enable maximum utility of the database a hierarchical approach has been adopted for its design. The intrinsic variability of biotic and chemical components of riverine ecosystems within South Africa has necessitated the differentiation of rivers into smaller units. Various spatial frameworks have been incorporated to facilitate useful manipulation of the available biological and chemical information. The primary level is the regional or geographic framework, the secondary level is the longitudinal differentiation and the tertiary level is the site.

2.1.1 Primary level: geographic frameworks

Three frameworks have been incorporated to allow for selection of sites and hence biological and chemical data within the regions defined below.

- **Water Quality Management Regions** (WQRegion; Appendix A), which are based on DWAF water chemistry data, were proposed at a secondary catchment level (Dallas *et al*. 1994). These have been refined using new information such as Bioregions (Day *et al*. in press.).

- **Bioregions** (Appendix B) are a refinement of the Biogeographic Regions, which were based on the biological distribution of aquatic organisms (Eekhout *et al.* 1997.). The Bioregions were defined following a workshop with twenty specialists, and take into account various physical factors such as altitude (Brown *et al.* 1996).

- **Political Regions** (*PolRegion*, Appendix C) are the political regions within South Africa and were deemed important because of provincial management considerations.

2.1.2 Secondary level: longitudinal differentiation *(Subregion)*

In addition to the above geographic frameworks, it was considered important to incorporate a measure that takes account of the longitudinal zonation of rivers. This zonation has been based on the biotic subregions developed at the bioregion workshop (Brown *et al.* 1996). The subregions associated with each bioregion are given in Appendix D. For example, rivers in the Fynbos Bioregion have been divided into four subregions, namely Mountain Stream, Foothill, Transitional and Lowland. In some instances additional subregions have been incorporated (given in italics). Bioregions and/or subregions for which no biological or chemical data are available in the database are in parenthesis.

2.1.3 Tertiary level: Site

Summary Site Table

Information on the sites in the database are tabulated for ease of viewing in a dynamic selection table (Summary Site Table) which includes the *Site Code*, details of the *River, Subregion, BioRegion, PolRegion* and *WQRegion.*

1. To select a Bioregion, WQRegion or PolRegion, click the appropriate button and select specific region from the drop-down list by clicking on the down-arrow.
2. To select a site, river, subregion, etc. or combination thereof, use drop-down lists by clicking on the down-arrow of the field-header.
3. To select sites by Study Reference, click the appropriate button and select Study Reference for associated biological or chemical data from the drop-down list by clicking on the down-arrow.
4. To sort a field alphabetically, click the appropriate sort button.
5. To view selected multiple sites, click the “Apply filter” button. The Detailed Site Table for each is then returned and may be viewed using the “next”, “previous”, “first” or “end” buttons.
6. To view details for a single site, double-click on the site record.
7. To exit Detailed Site Table, click close button.
8. To reset selection, click “Show all” button.

Detailed Site Table

Associated with each site is information on the:

- *WQRegion, BioRegion, PolRegion* into which the site falls,
- specifications of the *Subregion* and *RiverName*,
- latitude and longitude coordinates, and altitude.

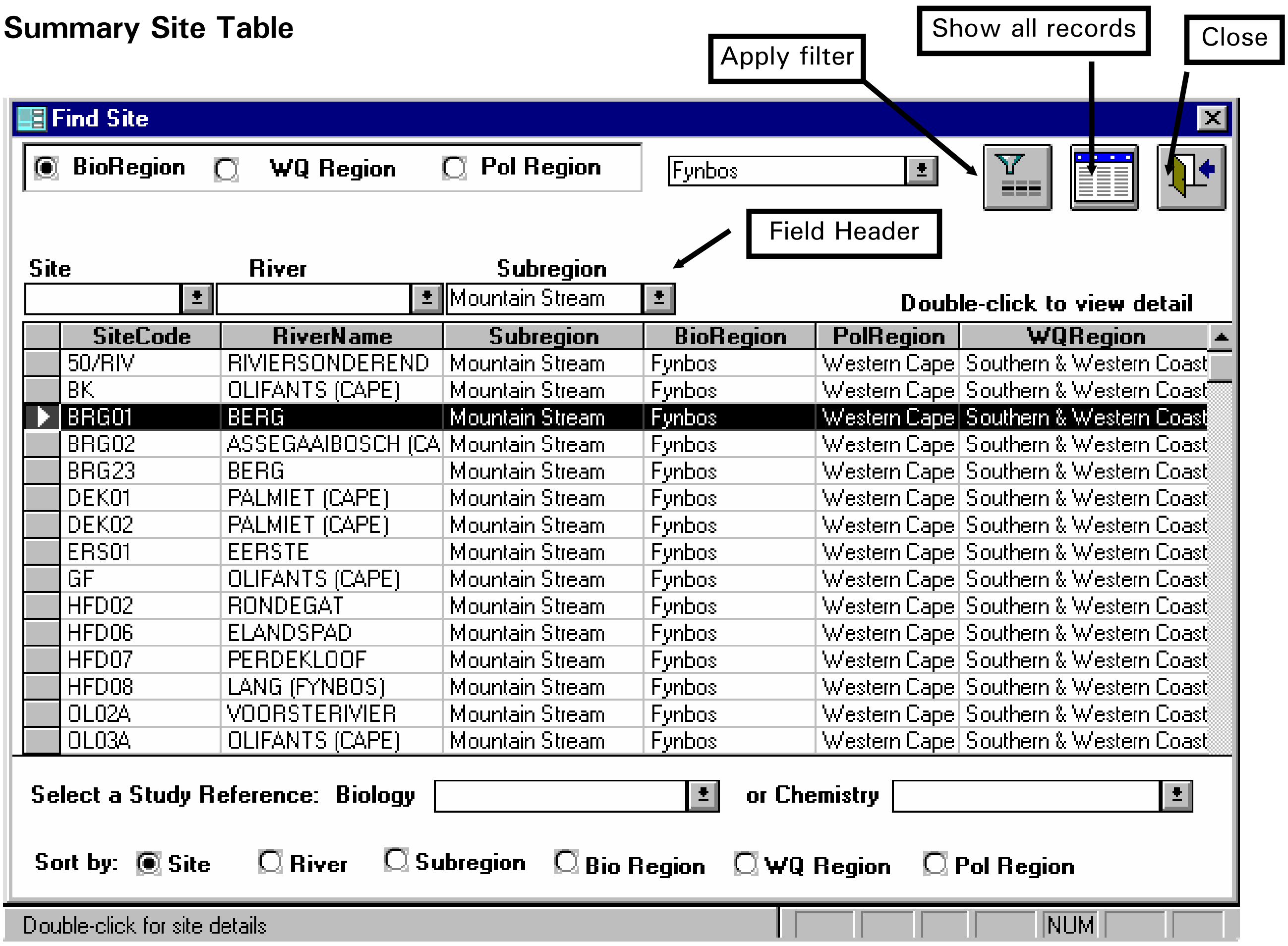
To view summarized information on the biology and chemistry for each site, select:

Site Visits (Biology): BioDate, Biotope (broad and specific), Study reference, Year

Site Visits (Chemistry): Chemdate, Study Reference, Year

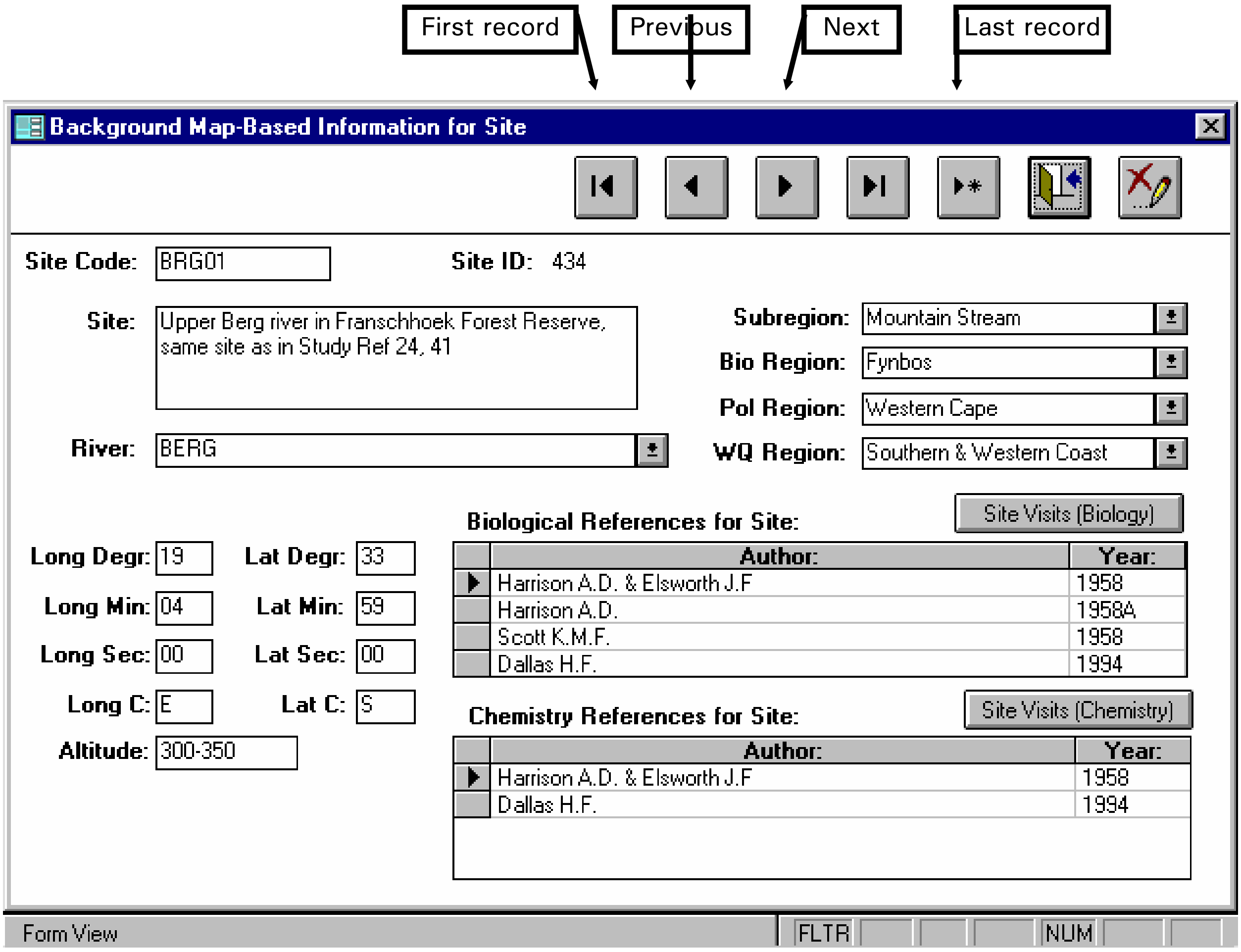
(Right-clicking on any field such as biodate, biotope, study reference, etc., allows one to sort or find specific information within the selected field).

Summary Site Table



SiteCode	RiverName	Subregion	BioRegion	PolRegion	WQRegion
50/RIV	RIVIERSONDEREND	Mountain Stream	Fynbos	Western Cape	Southern & Western Coast
BK	OLIFANTS (CAPE)	Mountain Stream	Fynbos	Western Cape	Southern & Western Coast
BRG01	BERG	Mountain Stream	Fynbos	Western Cape	Southern & Western Coast
BRG02	ASSEGAAIBOSCH (CA	Mountain Stream	Fynbos	Western Cape	Southern & Western Coast
BRG23	BERG	Mountain Stream	Fynbos	Western Cape	Southern & Western Coast
DEK01	PALMIET (CAPE)	Mountain Stream	Fynbos	Western Cape	Southern & Western Coast
DEK02	PALMIET (CAPE)	Mountain Stream	Fynbos	Western Cape	Southern & Western Coast
ERS01	EERSTE	Mountain Stream	Fynbos	Western Cape	Southern & Western Coast
GF	OLIFANTS (CAPE)	Mountain Stream	Fynbos	Western Cape	Southern & Western Coast
HFD02	RONDEGAT	Mountain Stream	Fynbos	Western Cape	Southern & Western Coast
HFD06	ELANDSPAD	Mountain Stream	Fynbos	Western Cape	Southern & Western Coast
HFD07	PERDEKLOOF	Mountain Stream	Fynbos	Western Cape	Southern & Western Coast
HFD08	LANG (FYNBOS)	Mountain Stream	Fynbos	Western Cape	Southern & Western Coast
OL02A	VOORSTERIVIER	Mountain Stream	Fynbos	Western Cape	Southern & Western Coast
OL03A	OLIFANTS (CAPE)	Mountain Stream	Fynbos	Western Cape	Southern & Western Coast

Detailed Site Table



2.2 Biological and Chemical Data

This is the main form for data entry and/or viewing. Biological and chemical data for each site are linked to the site in a hierarchical manner as follows:

Biological data

CODE	DESCRIPTION
Site	Site Code for a specific site
SiteVisitBio	Site Code plus BioDate at which the biological data was collected
SiteVisitBioBiotope	Site Code plus BioDate plus the Biotope at which the biological data was collected
SiteVisitBioBiotopeTaxon	Site Code plus BioDate plus Biotope plus the actual abundance of each taxon recorded

Chemical data

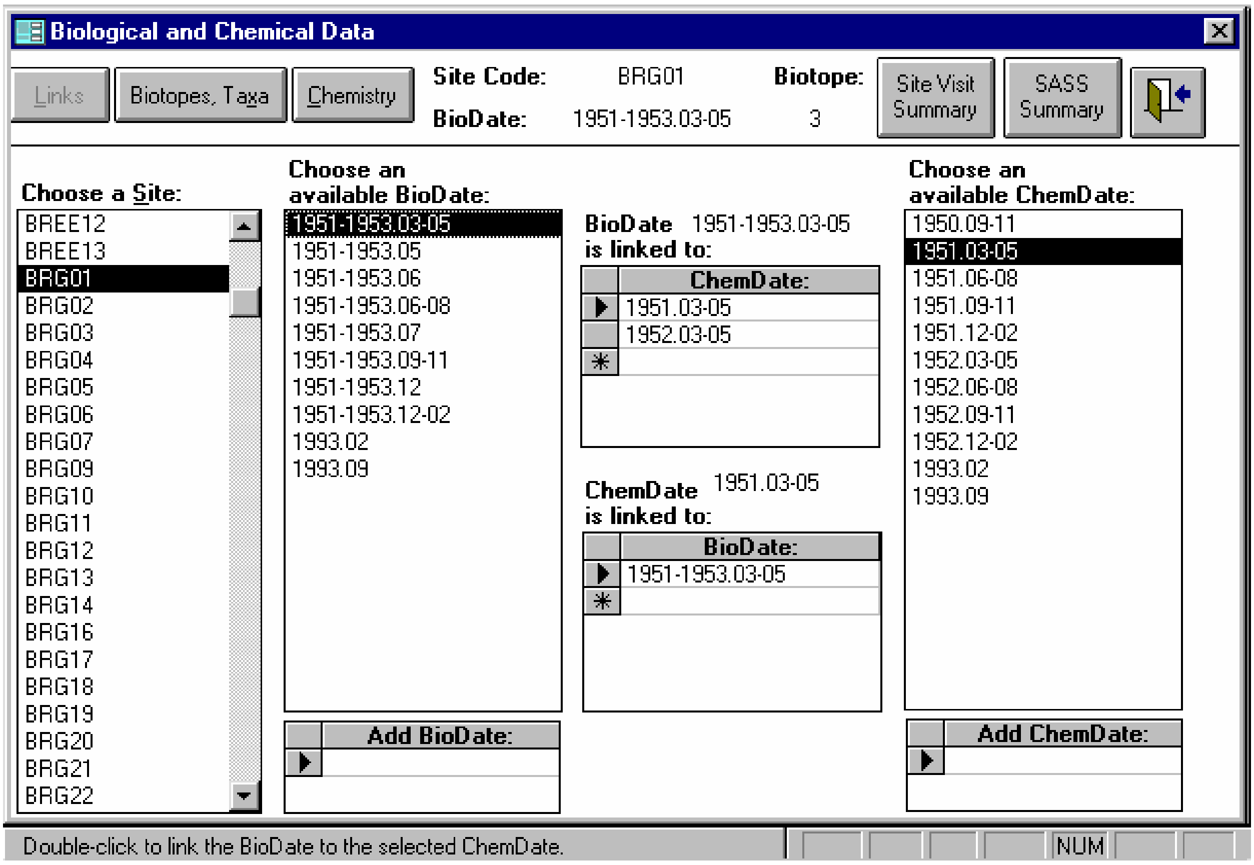
CODE	DESCRIPTION
Site	Site Code for a specific site
SiteVisitChem	Site Code plus ChemDate at which the biological data was collected
SiteVisitChemValue	Site Code plus ChemDate plus value for each chemical component recorded

2.2.1 Biological chemical date link form

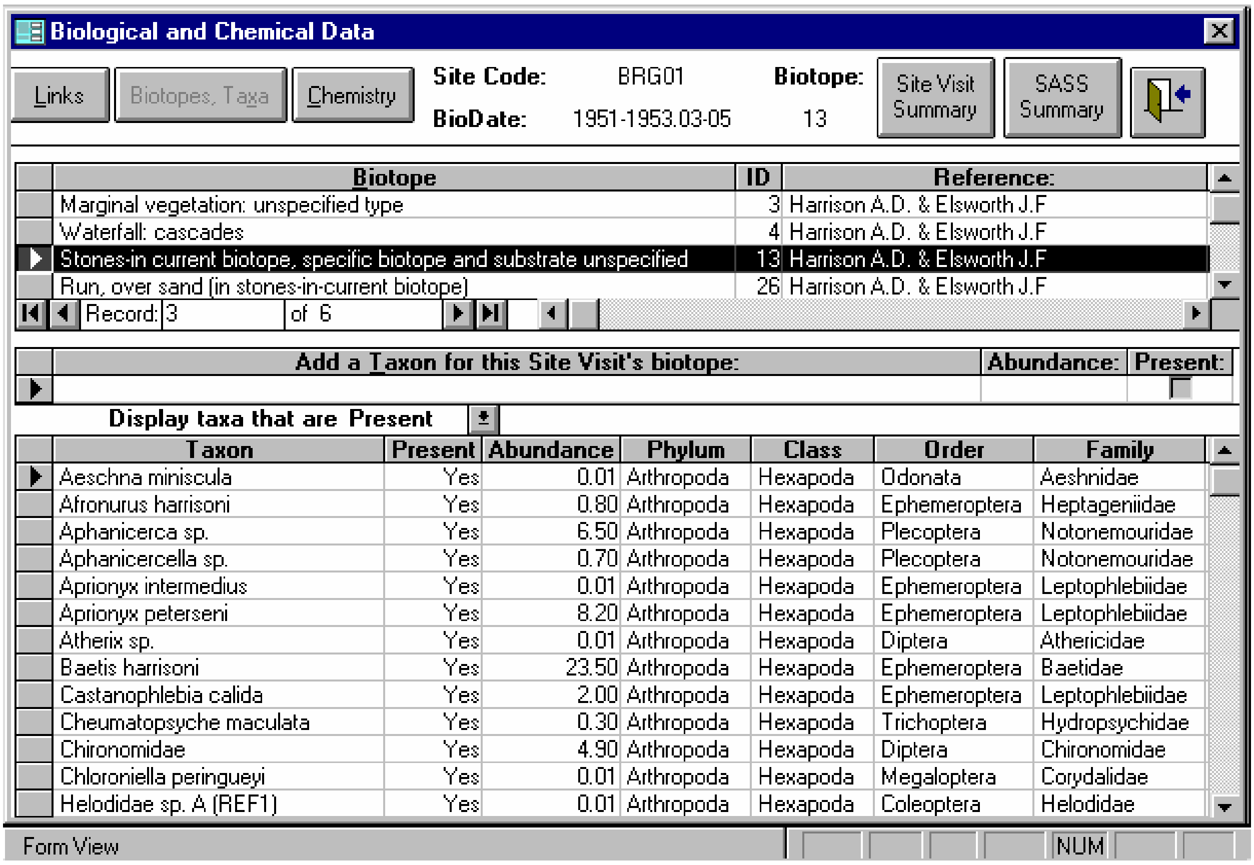
The following procedure outlines the steps taken when viewing data. Detailed explanations of the terms and conventions used are given in section 2.2.2.

1. Select a *site* (enter first letter of site and then scroll using the down-arrow).
2. Select a *biodate* from the list displayed. If chemical data are also available for this site and biodate, then the linked *chemdate* is automatically selected. If chemical data are not available, no chemdate is displayed as being linked to the biodate. Details of the links are given and there is a facility to delete and/or add additional dates.
3. Click *Biotopes,Taxa* and choose a biotope from the list available for the selected site and biodate. The taxa present in the selected biotope are displayed and the abundance as a percentage is given. Absent taxa (i.e. taxa not recorded at the site or biodate within the specified study) can be viewed by clicking on the right drop-down arrow. Selecting a new biotope provides a new list of associated taxa.
4. Associated (or additional) chemical data can be viewed by selecting the *Chemistry* button. If the displayed chemistry is not linked to the biological information, an appropriate warning is given.
5. A *Site Visit Summary*, i.e. a summary of all taxa at the site (biotopes combined), may be obtained by clicking the appropriate button.
6. A *SASS Summary*, i.e. SASS scores calculated for the site including SASS4 Score, Number of Taxa and Average Score per Taxon (ASPT) and Number of SASS biotopes, may be obtained by clicking the appropriate button.

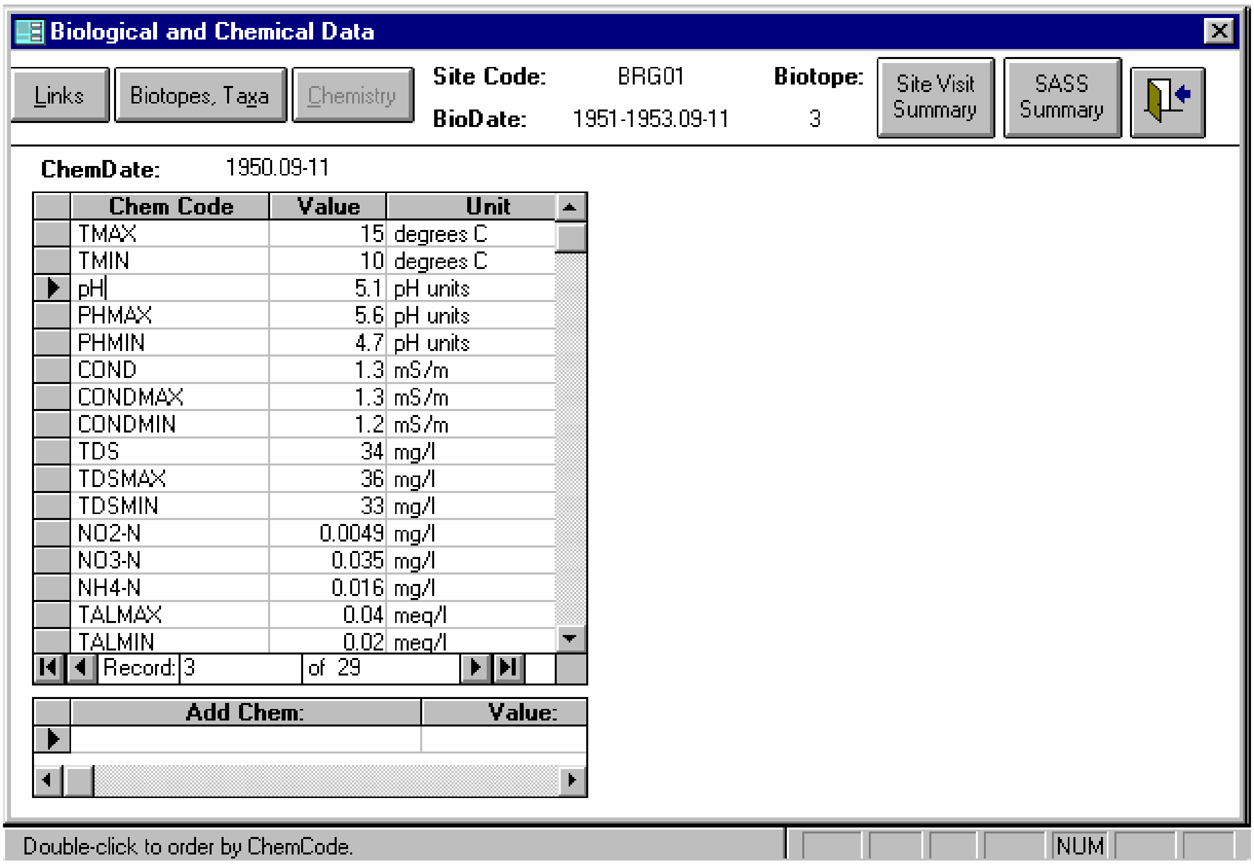
Biological and Chemical Data



Biotopes, Taxa Form



Chemistry Data



Chem Code	Value	Unit
TMAX	15	degrees C
TMIN	10	degrees C
pH	5.1	pH units
PHMAX	5.6	pH units
PHMIN	4.7	pH units
COND	1.3	mS/m
CONDMAX	1.3	mS/m
CONDMIN	1.2	mS/m
TDS	34	mg/l
TDSMAX	36	mg/l
TDSMIN	33	mg/l
NO2-N	0.0049	mg/l
NO3-N	0.035	mg/l
NH4-N	0.016	mg/l
TALMAX	0.04	meq/l
TALMIN	0.02	meq/l

2.2.2 Explanation of terms and conventions used in biological and chemical data tables

a. Biodates and Chemdates

"Biodate" and "Chemdate" refer to the dates at which biological and chemical data were collected respectively. Sampling frequency was highly variable, with some records being one-off "spot" samples, while others are the means of weekly, monthly, seasonal or annual samples. The presentation of data in reports and published papers is also highly variable, with results being presented either as one-off samples with different degrees of detail as to day, month and year of sampling, or as monthly, seasonal or yearly means. In some cases, results are of monthly or seasonal data, presented as a mean over a few years (although data that have been used in this database never span more than three years). To facilitate querying the bio- and chemdates have been standardized (Year.Month.Day) and "Sort Month", "Sort Year" and "Sort Season" allocated to each. To allow this, some dating conventions have had to be established. As with all conventions, these should be regarded with both caution and flexibility, since while they render the accessing of data more convenient, they also decrease the accuracy with which the data are presented.

The dating hierarchy is linked to the actual "Biodates" which are unique to each study reference. The dating conventions are as follows:

1. Where two months are linked, the first month is chosen as the representative month; where more months are linked together, the middle month is used.

2. In cases where the study reference provides only seasonal means, the mid-month of that particular season is used. In cases where the reference provides no details as to which months constitute each season, the mid-month used in the season "convention" is used.

3. *Seasons*: Unless specified otherwise, each season is assumed to comprise the following months:
   - autumn (AUT): March (MAR), April (APR), May (MAY)
   - winter (WIN): June (JUN), July (JUL), August (AUG)
   - spring (SPR): September(SEP), October (OCT), November(NOV)
   - summer (SUM): December (DEC), January (JAN), February(FEB)

   Where the reference does assign different months to each season, these months are used instead.

4. *Years*: Where records refer to samples as a mean over two years, the first year is taken as the "Sort Year". Where three years are used, it is the second that is taken. No data from records that have been averaged over more than three years are used.

Some inaccuracies are inherent to such a hierarchical system and to counteract this to some degree, the following warning codes have been added.

CODE	TYPE	DESCRIPTION
Spot	Spot sample	Data based on a one-off survey
MP	Month Pool	Data were seasonal and Sort Month was deduced by convention
YP	Year Pool	Data taken in the same month were presented together, but as a mean over several years
BP	Both Pool	Both month and year sort dates are artificial and records are presented as seasonal means, over a number of years.

Linking biological and chemical data

One of the reasons for the development of this database was to facilitate a linking of biological and chemical data. Whilst acknowledging that there are inherent problems in doing this, there is sufficient utility in such a function. For example, one is able to ascertain the range of pHs at which a particular species or family have been recorded. It was therefore necessary to link the biological and chemical data. Problems arose due the inconsistent nature in which the data were reported, making it impossible to link the data in a straightforward manner. To overcome this problem, the sampling dates from each study have been assessed, and a subjective judgment made as to the best matched chemical and biological data, for each site. When biological and chemical samples were taken at the same time, however, matching was automatic. The rules that have been applied to the linking process are as follows:

Where biological and chemical sampling were not simultaneous, or data were not presented in the same time format:

1. data that were not taken in the same years were never linked.
2. if either the "Biodate" or the "Chemdate" was presented as a seasonal mean, then the mid month of that season was linked to the records for the appropriate month of the other data set.
3. If no direct date match was found, data taken at reasonably close intervals were linked, provided

those intervals did not mean that data fell into different seasonal categories.

4. Each set of records could only be linked once, unless records included the means of several years. For example, biological data with a "Biodate" of 1951-1952.08 could be linked to chemical data with "Biodates" in both August 1951, and August 1952, should these data be available. Such a system does, however, mean that the records are open to duplication, and users should be aware of this when running queries.

A conservative attitude was adopted for the linking of these data sets, such that not all the biological data stored in the database have been linked to chemical data, and vice versa. The linking of data within each study is documented in Appendix G.

b. Biotopes

This is the level at which the biological information was collected. A hierarchical structure was adopted to take into account the numerous biotopes sampled and the variability in both terminology and methodology between studies. Each of the documented biotopes has also been assigned to SASS (South African Scoring System) biotope that provides a more uniform basis from which comparisons can be made (Appendix E).

c. Taxa (Biological Data)

The presence or absence of each taxon has been included in a yes/no manner, and when present the abundance of the taxon is expressed as a percentage occurrence because of the semi-quantitative nature of much of the data. Abundances given as "p" in the study text, indicating that a taxon was present but in a very low abundance, have been reported as 0.01. If a taxon is present but no abundance was given in the study reference, the abundance field is blank. Absent taxa are those not recorded at particular sites or at particular time periods within a study reference.

d. Chemical Data

Chemical data were recorded at forty of the forty-three sites documented in this database. The variables measured and units reported varied between studies. These units have been standardized into SI units where possible, and conversions made where applicable. A complete list of all studies in the database is given in Appendix F and detailed study references in Appendix G. A full list of the chemical variables for which we have records is given in Appendix 4.3. of Dallas *et al.* (1994). In certain studies chemical values were given as "trace", "not detected" or "0.0". On the basis of reported chemical values for each variable, the following standardization was adopted:

Variable	**Trace or "not detected" value**
Total Suspended Solids	0.01
Anions and cations	0.01
Total alkalinity	0.01
Fluoride	0.01
Free CO_2	0.01
Metals	0.001
Kjeldahl nitrogen, ammonium and phosphorus	0.001
Nitrite and nitrate	0.0001

e. Site Visit Summary

A summary of all the taxa present at a particular site on a particular date is tabulated by taxon name and biotope. Right-clicking on either field will enable the data to be sorted or an entry located.

f. SASS Summary

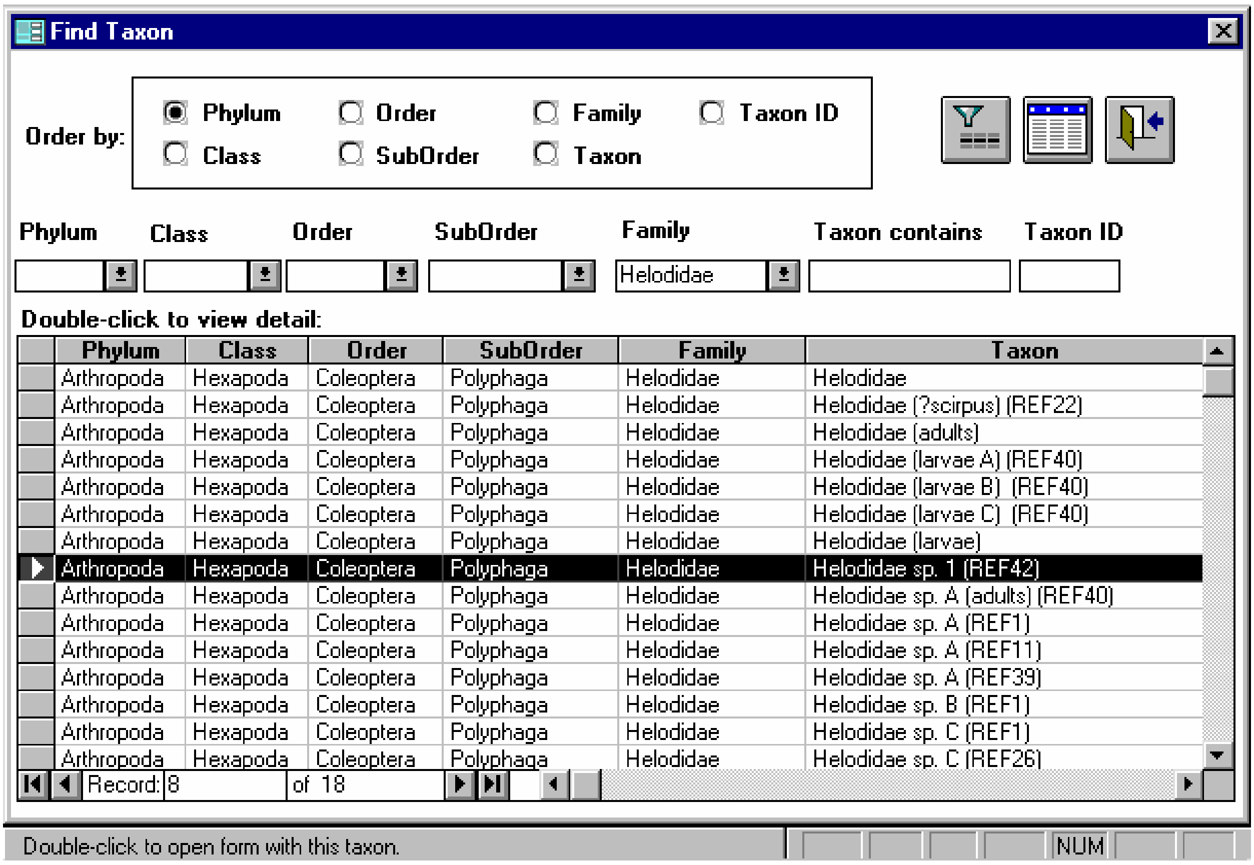
The South African Scoring System (SASS) is a rapid bioassessment method, based on the sensitivity/tolerance of macroinvertebrates to water quality impairment. It is designed to assist in the detection and monitoring of water quality in riverine ecosystems. Application of SASS scores to historical data in the database provides a crude means of ranking or ascertaining the extent of water quality impairment at each site. It is limited in that certain studies were restricted to a single biotope whilst others incorporated numerous biotopes which are then considered collectively. Certain data are the result of a single site visit whilst others are more intensive and the grouping of months and/or years. These aspects need to be taken into consideration if SASS Summary information is used. Each SASS taxon recorded for each site visit is used to calculate Total Score, Number of Taxa and ASPT for the site. The number of SASS biotopes, i.e. stones-in-current, stones-out-of-current, marginal vegetation, aquatic vegetation, gravel, sand and mud, is also calculated for each site visit.

2.3 Taxonomy

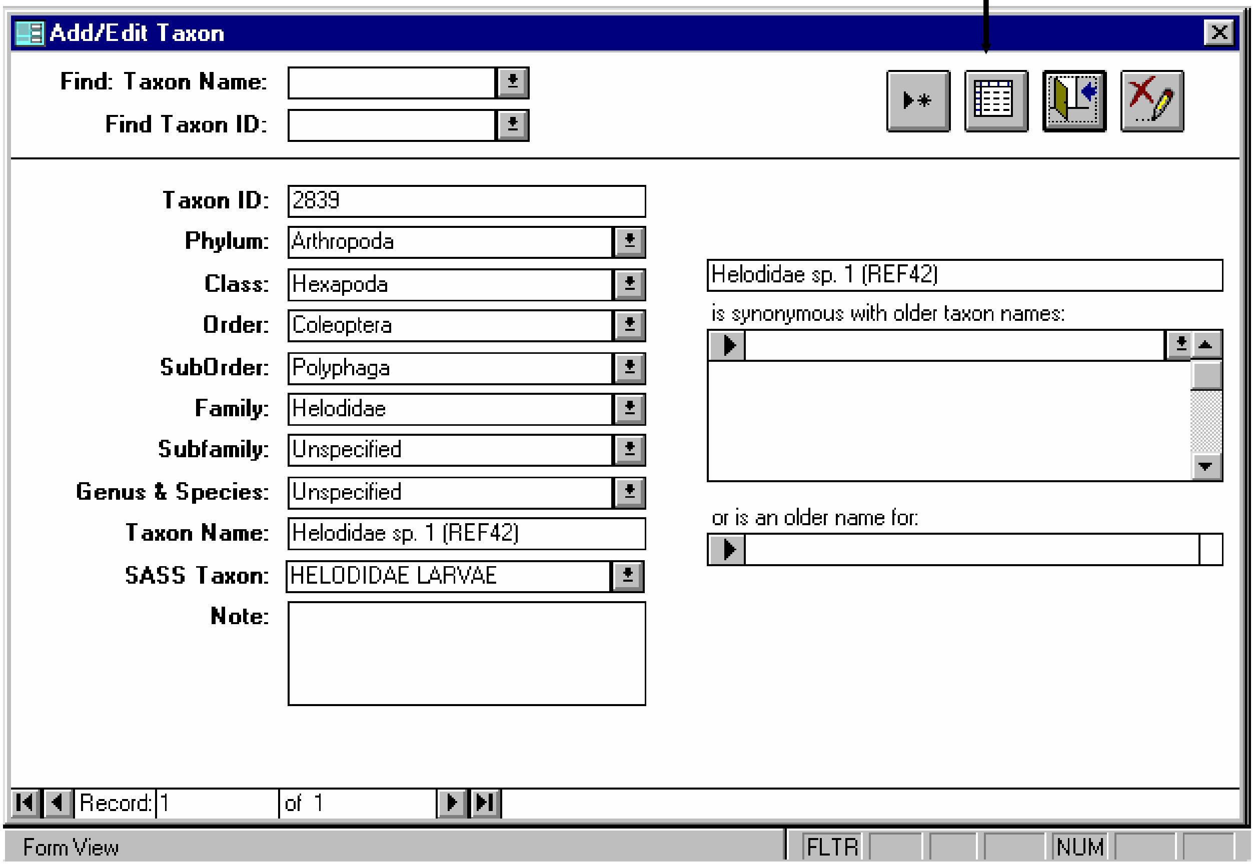
Each species has been given a unique, numerical genus/species code. The state of flux of the taxonomy and inconsistent historic record of species names is to be noted, and caution is advised when querying on the lower taxonomic levels (e.g. species). Synonymous names and all taxonomic levels have been incorporated when known. The taxonomic details of each taxon may be accessed via the *Taxonomy* button.

1. The “Show all” button displays all recorded taxa.
2. Select the *phylum, class, order, sub-order and/or family* using drop-down lists. (Enter first letter and use scroll down arrow).
3. If one particular taxon’s details are of interest, double-click on record to get details of the taxon.
4. Multiple taxa (e.g. all Helodidae) may be viewed by selecting the appropriate group from the drop-down list and clicking the “Apply Filter” button. In the detailed form right and left arrows move between selected records. The selected taxa may be viewed simultaneously using the Datasheet view button. Right-clicking on the field-header enables the data to be sorted or searched. To return to the Taxonomy Details Form, click View|Form.
5. If the taxon is known under a previous name, or is itself a newer name for an older taxon, this may be ascertained/edited on this form.

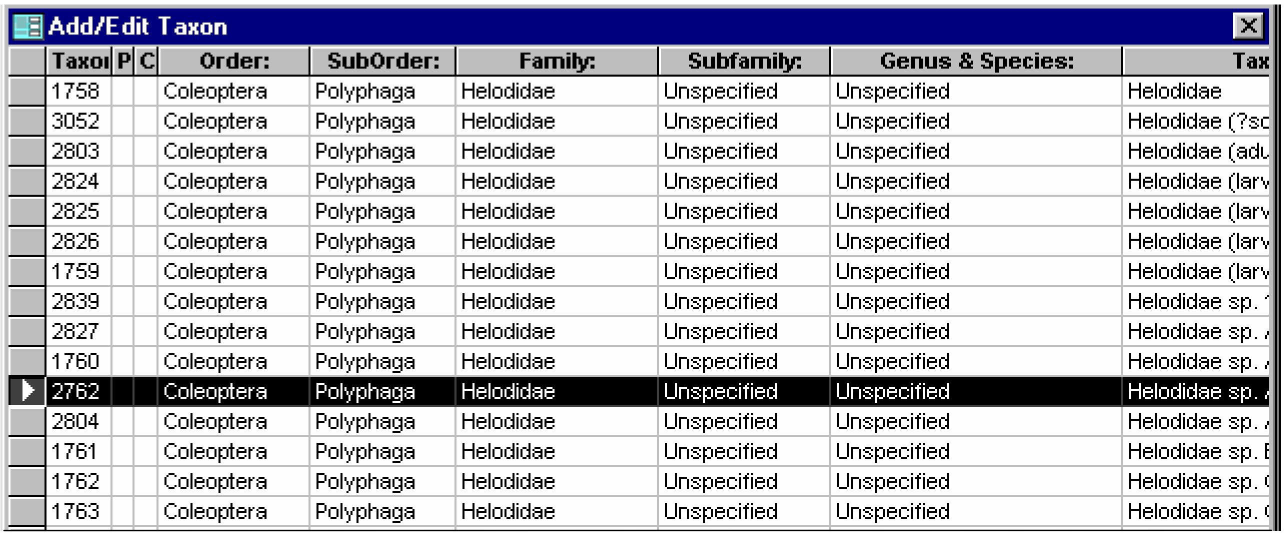
Taxonomy Summary Data



Taxonomy Details Data



Datasheet View



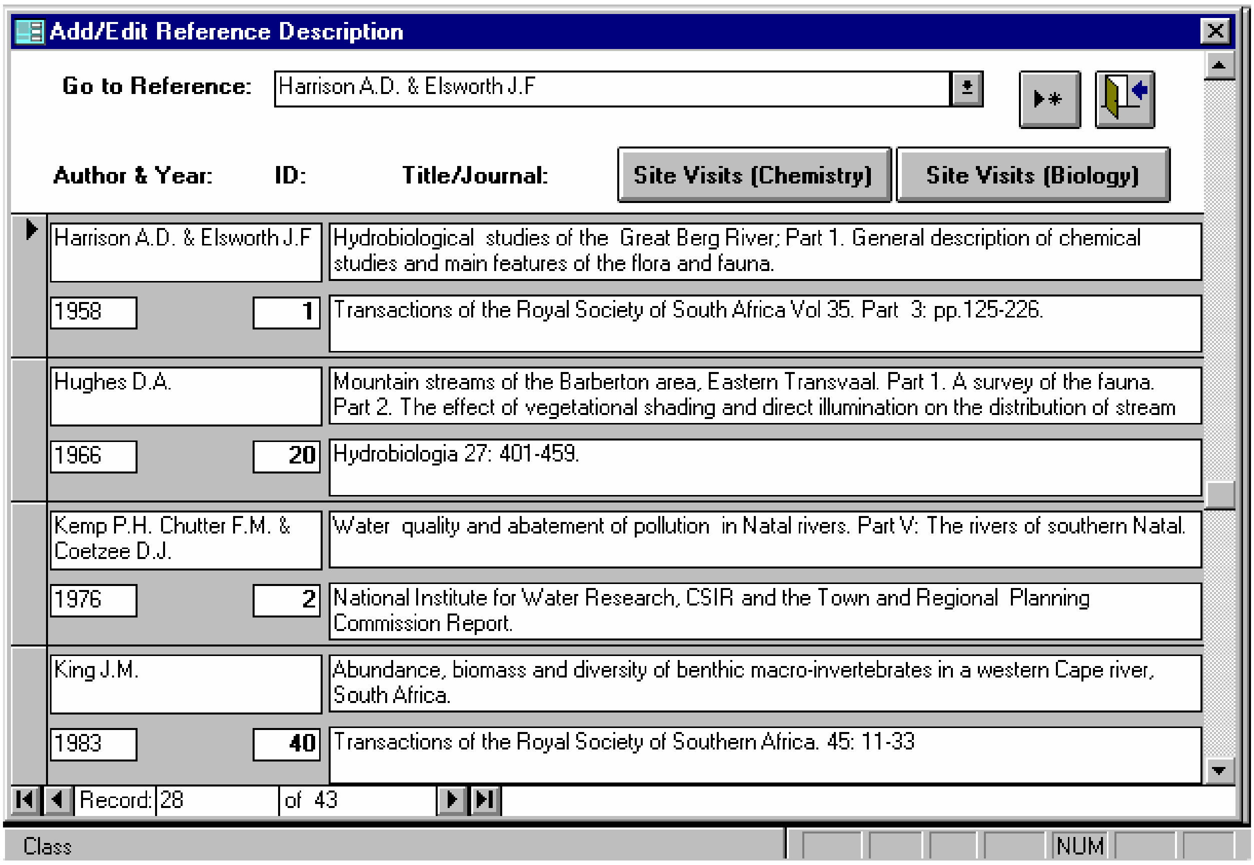
Add/Edit Taxon

Taxo	P	C	Order:	SubOrder:	Family:	Subfamily:	Genus & Species:	Tax
1758			Coleoptera	Polyphaga	Helodidae	Unspecified	Unspecified	Helodidae
3052			Coleoptera	Polyphaga	Helodidae	Unspecified	Unspecified	Helodidae (?sc
2803			Coleoptera	Polyphaga	Helodidae	Unspecified	Unspecified	Helodidae (adu
2824			Coleoptera	Polyphaga	Helodidae	Unspecified	Unspecified	Helodidae (larv
2825			Coleoptera	Polyphaga	Helodidae	Unspecified	Unspecified	Helodidae (larv
2826			Coleoptera	Polyphaga	Helodidae	Unspecified	Unspecified	Helodidae (larv
1759			Coleoptera	Polyphaga	Helodidae	Unspecified	Unspecified	Helodidae (larv
2839			Coleoptera	Polyphaga	Helodidae	Unspecified	Unspecified	Helodidae sp.
2827			Coleoptera	Polyphaga	Helodidae	Unspecified	Unspecified	Helodidae sp.
1760			Coleoptera	Polyphaga	Helodidae	Unspecified	Unspecified	Helodidae sp.
2762			Coleoptera	Polyphaga	Helodidae	Unspecified	Unspecified	Helodidae sp.
2804			Coleoptera	Polyphaga	Helodidae	Unspecified	Unspecified	Helodidae sp.
1761			Coleoptera	Polyphaga	Helodidae	Unspecified	Unspecified	Helodidae sp.
1762			Coleoptera	Polyphaga	Helodidae	Unspecified	Unspecified	Helodidae sp.
1763			Coleoptera	Polyphaga	Helodidae	Unspecified	Unspecified	Helodidae sp.

2.4 Study References

The author, year, title and journal details are given for each study in the database (see Appendices F and G for details). Study references are numerically coded and linked to both the biological and chemical data. Details of the sites for which biological and chemical data have been collected for each study reference may be viewed using *"Site Visits (Chemistry)"* and *"Site Visits (Biology)"*. A specific reference may be selected using the "Go to Reference" field.

Study References



2.5 Picklist Options

Picklist options is an administrative function, used to change values that are displayed in certain drop-down lists. It need not be accessed by most users.

3. QUERY CENTRE

The database has been designed to facilitate querying in a manner that only requires a basic knowledge of Microsoft Access and Excel. The Query Centre has three pre-defined query frameworks and within each it is possible to select the following:

3.1 Biology

Queries created from this form include only biological records. Using a series of drop-down lists and selection boxes within the following categories, queries can be streamlined.

- Taxonomy (Phylum, Class, Order, Family, Genus species etc., including wildcards as *)
- Biotope (SASS, broad, specific, substratum, description)
- Region (bioregion, water quality region, political region), subregion, river and site(s)
- Date (year, month, season)
- Study reference
- SASS has been added to enable selection of sites with SASS4 Scores, number of taxa, ASPT or number of SASS biotopes less than, equal to or greater than a specific value. The operator can be changed from “and” to “or” thereby enabling the selection of various combinations of SASS4 Scores and ASPTs.

3.2 Chemistry

Queries created from this form include only chemical records. Using a series of drop-down lists and selection boxes within the following categories, queries can be streamlined.

- Chemical parameter(s)
- Region (bioregion, water quality region, political region), subregion, river and site(s)
- Date (year, month, season)
- Study reference

3.3 Chemical parameters linked to biology

Queries created from this form return chemical records that have been linked to biological records. Using a series of drop-down lists and selection boxes within the following categories, queries can be streamlined.

- Chemical parameter(s)
- Taxonomy (Phylum, Class, Order, Family, Genus species etc., including wildcards as *)
- Region (bioregion, water quality region, political region), subregion, river and site(s)
- Date (year, month, season)
- Study reference

- SASS has been added to enable selection of sites with SASS4 Scores, number of taxa, ASPT or number of SASS biotopes less than, equal to or greater than a specific value. The operator can be changed from "and" to "or" thereby enabling the selection of various combinations of SASS4 Scores and ASPTs.

3.4 Selecting Criteria and running queries in Microsoft Access

For each of the above queries it is possible to specify criteria such that a particular taxon and/or chemical variable, for a particular BioRegion, subregion and river, etc. is selected. Some general rules when specifying criteria are given below:

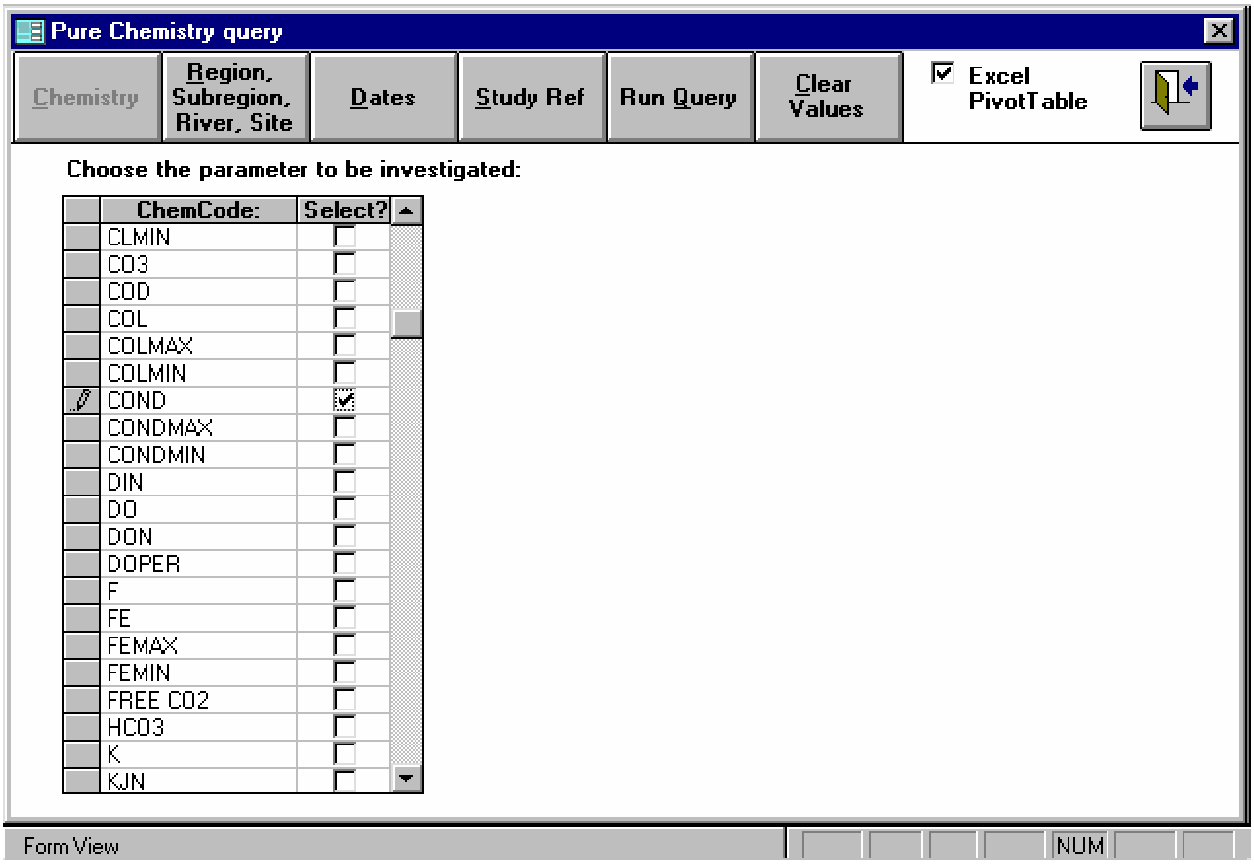
- In free text fields, criteria may be typed directly, including any wildcard characters. Wildcard characters are "*" for any number of unknown characters (e.g. B* for Berg, Bree, Bronkhorst, etc.), or "?" for one unknown character (e.g. m?n, will return man, mon, min, mtn, etc.). In drop-down lists, wildcard characters are only available where the label is marked with an "*".
- When a free text field or selection box is left blank, no criteria are set for that field, and all available information is returned.
- Certain combinations may result in no data being returned, e.g. selecting fynbos bioregion and upland plateau subregion. The user needs to check such combinations using the sites form or manual.

The query is executed by pressing the Run Query button. By default these queries produce a Microsoft Excel PivotTable which allows complex manipulation and dynamic selection of information at all levels. The "Chemistry" and "Chemical parameters linked to biology" queries may also be queried within Microsoft Access by unselecting the Excel PivotTable. Statistical information is generated for each chemical parameter selected including average, standard deviation, minimum, maximum, range and median values. "Value Results Set", "Summary Results Set" and "Responsible Taxa" can be generated, manipulated and exported to Excel using the File/Output to command. The procedures to query "Chemistry" and "Chemical parameters linked to biology" are as follows:

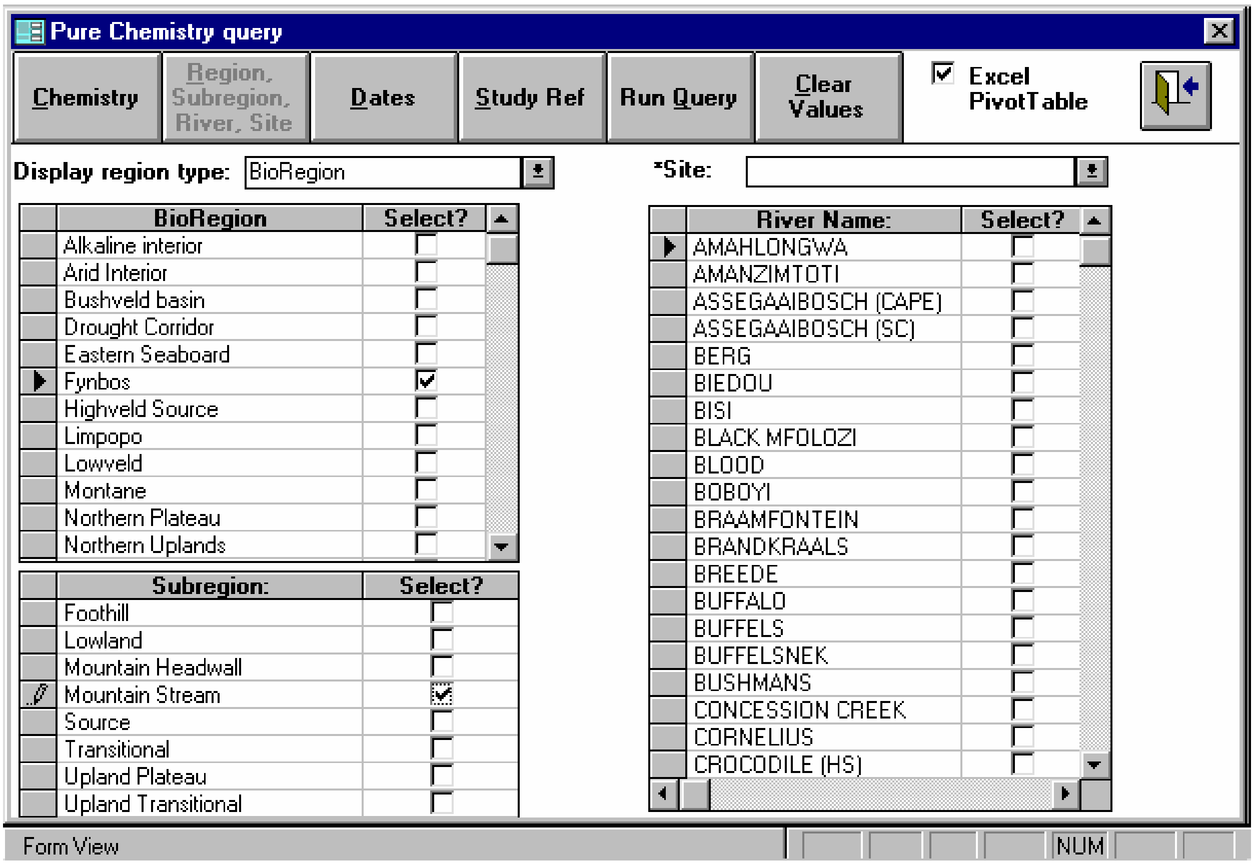
3.4.1 Chemistry query

1. Select chemical variables by clicking in boxes (Example: select COND, pH, TDS and TSS) using the scroll-down arrow if necessary. If all available chemical variables are required limit the data set using other parameters such as study reference or river name.
2. Select region type to be displayed using drop-down list. Select one or more regions, subregions and/or rivers or select a specific site. (Example: select bioregion using drop-down list, select Fynbos in bioregion and Mountain Stream in subregion lists).
3. Select a particular month or season, or limit results to a particular type of chemdate (e.g. Spot-sample). A specific year and/or chemdate may also be selected.
4. Select a particular study reference if required.
5. Unselect Excel PivotTable.
6. Run query.

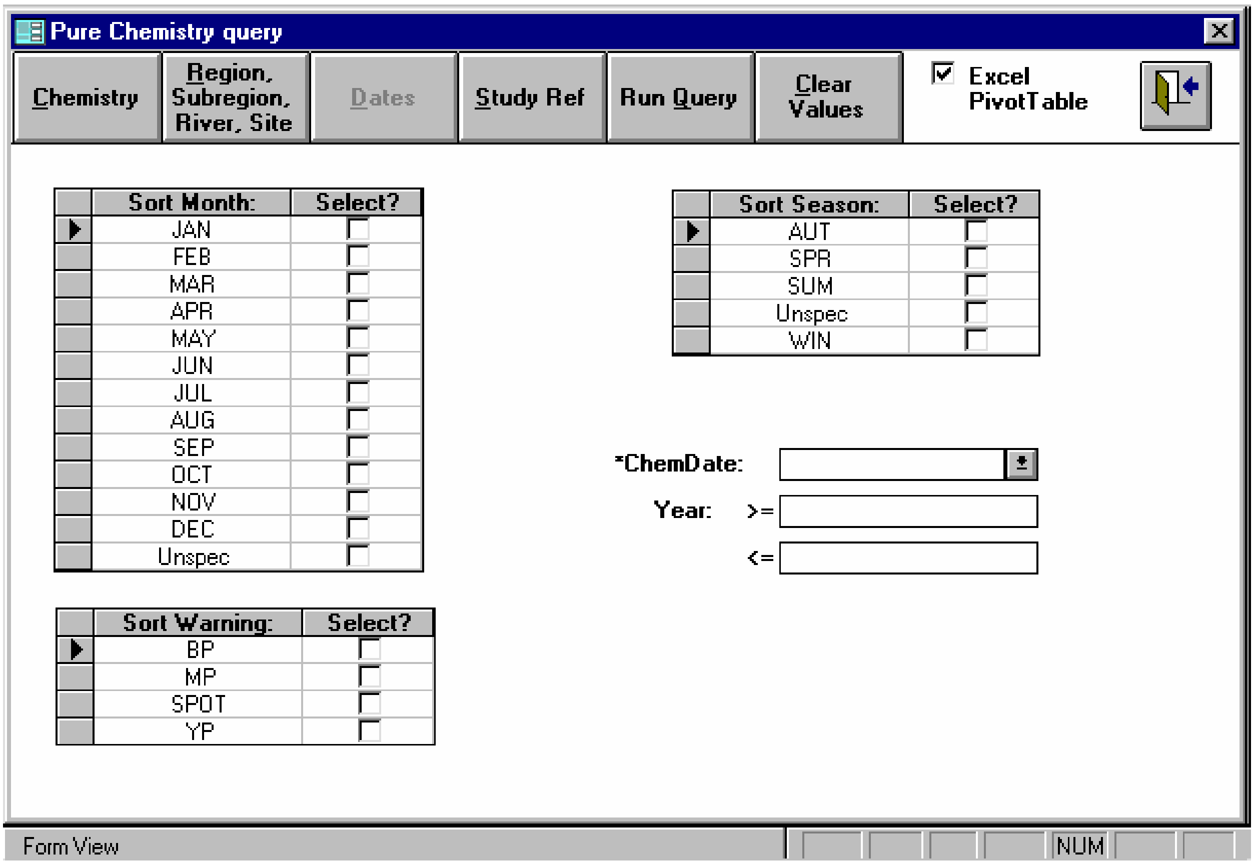
1. Select chemical variables



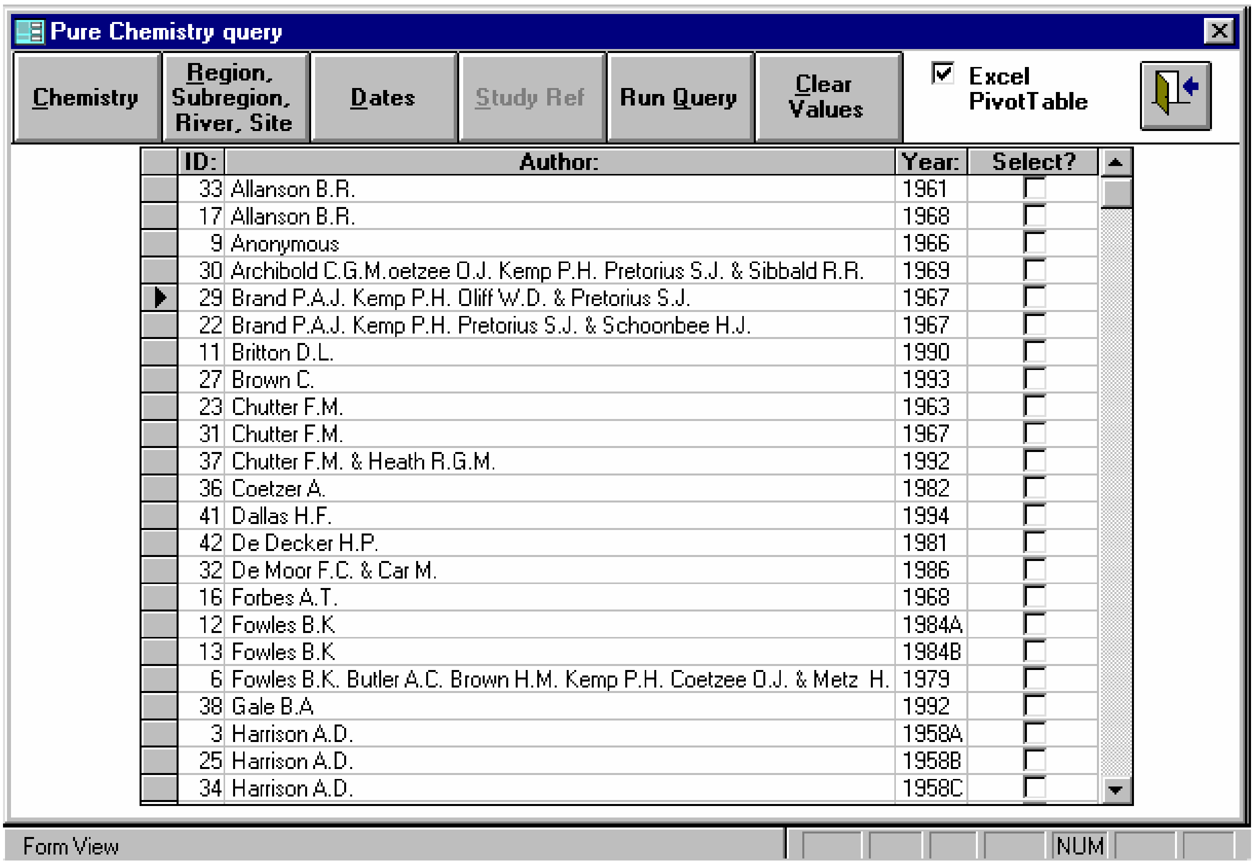
2. Select a region, subregion, river and/or site (all are returned if none are selected)



3. Select a month, season, year, specific chemdate or type of chemdate



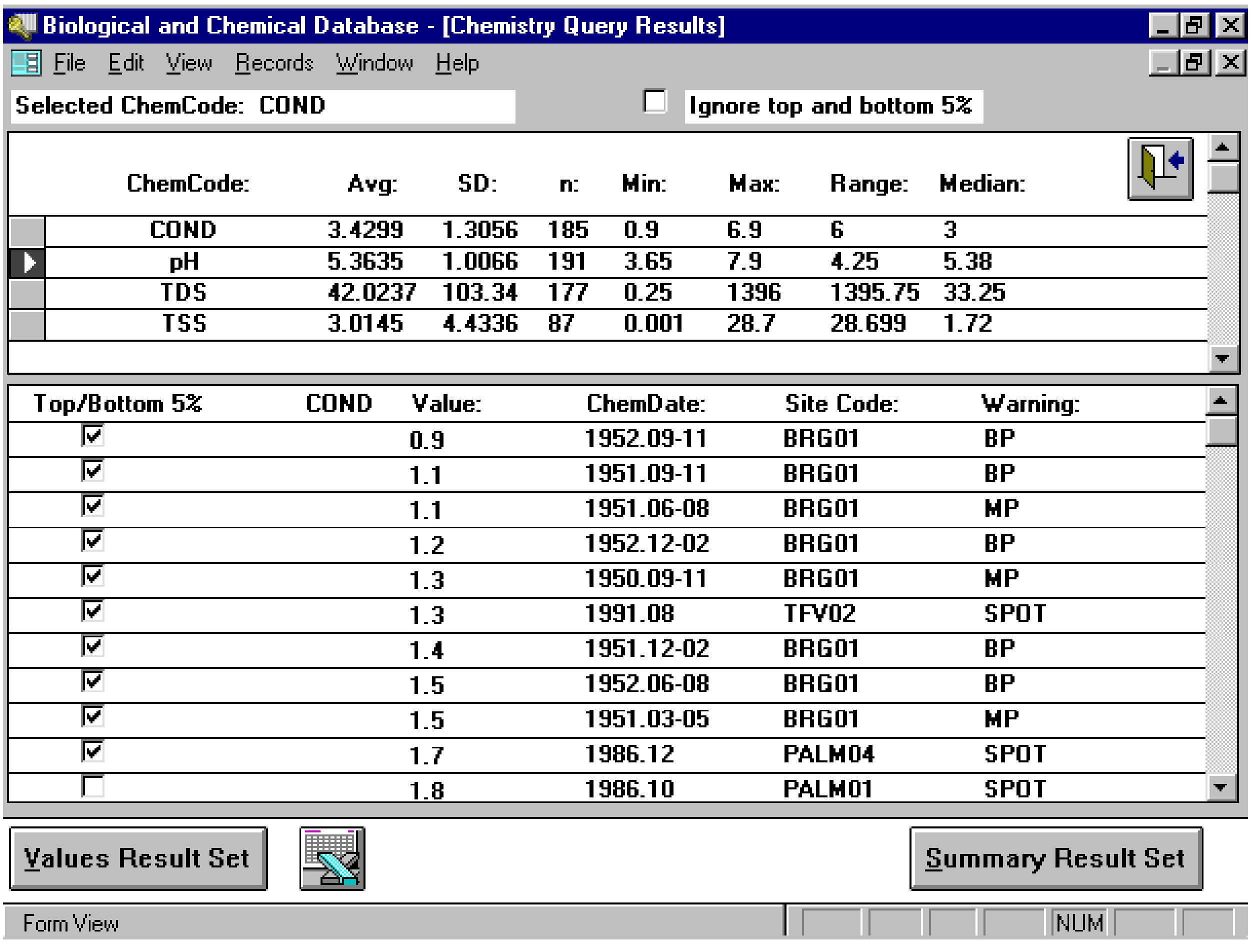
4. Select study reference



Results of chemistry query

The average (Avg), standard deviation (SD), number of records (n), minimum (min), maximum (max), range and median values for each selected chemical variable are returned. Additional features include:

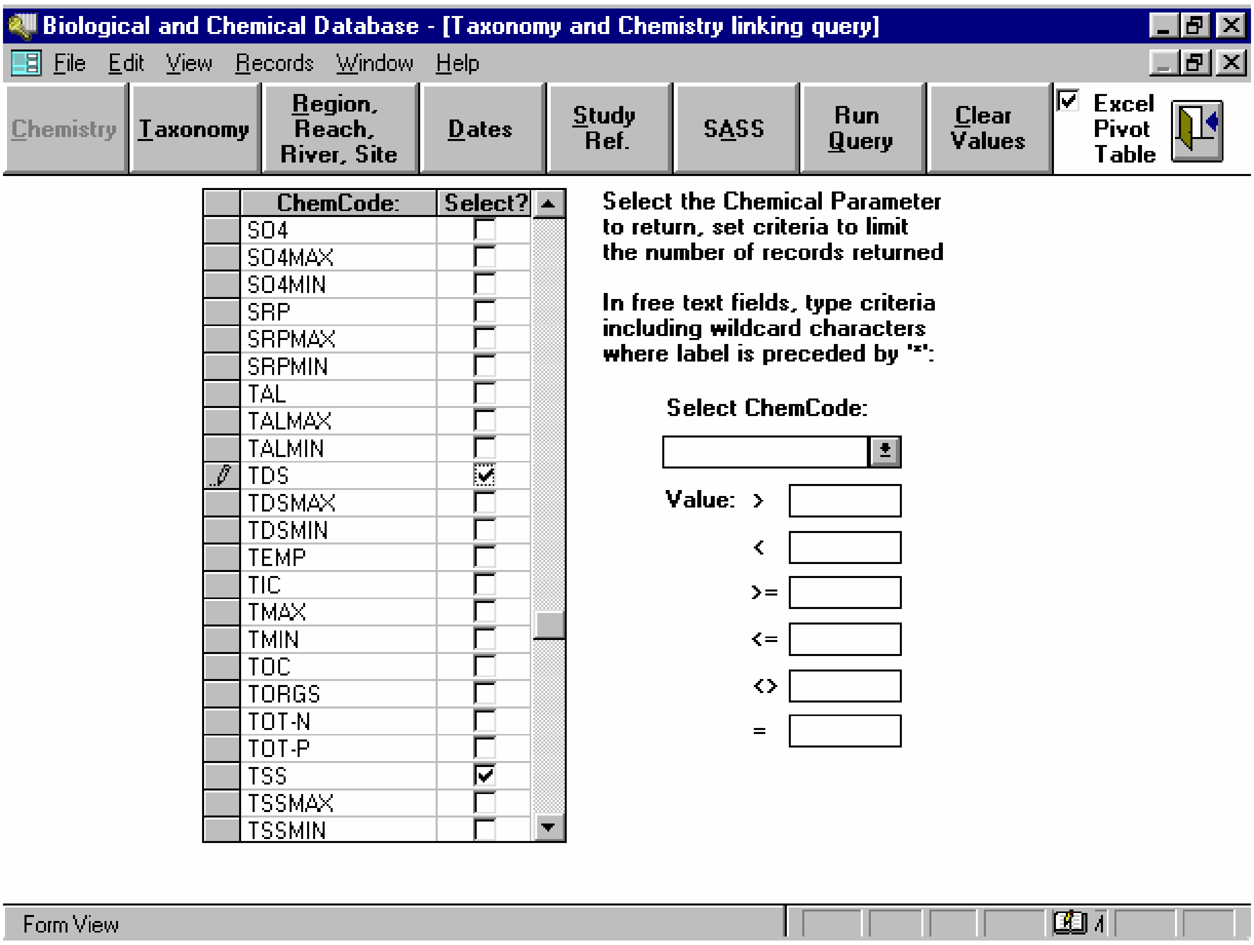
- Detailed data for each variable which can be viewed below the summary data by selecting the appropriate variable,
- The upper and lower 2.5% values can be omitted (i.e. the exclusion of outliers) from the statistical results by clicking the "Ignore top and bottom 2.5%. Those values that are excluded are indicated in the Top/Bottom 2.5% column.
- The "Values Result Set" is a datasheet of all values used in the analyses, including information on the sitecode, chemdate, bioregion, subregion, and latitude and longitude co-ordinates.
- The "Summary Result Set" is a datasheet summary of the statistical results for the selected chemical variables. Normal manipulation of data within the spreadsheet is possible and data may be exported or printed to most spreadsheet packages. To exit "Summary Result Set", select File/Close on Microsoft Access menu.
- Normal manipulation of data within the datasheets is possible and data may be exported or printed. To exit, select File/Close on Microsoft Access menu.



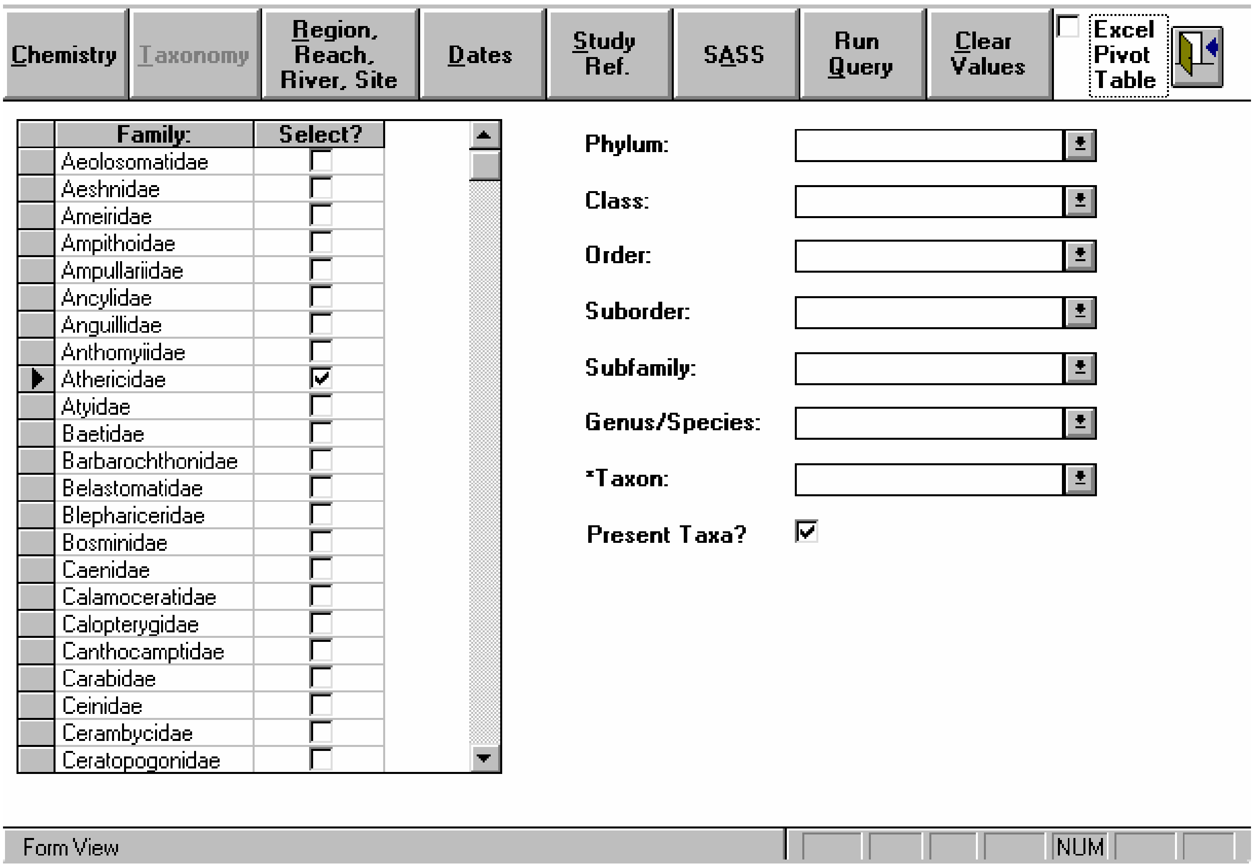
3.4.2 Chemical parameters linked to biology query

1. Select chemical variables by clicking in boxes (Example: select COND, pH, TDS and TSS) using the scroll-down arrow if necessary. Specific ranges for single variables may also be selected using >, < or =.
2. Select taxonomic group by clicking on a specific family or using drop-down lists for phylum, order, etc. A specific genus may be selected using a wildcard "*" character. (Example: select Family Athericidae). By default those taxa present at a site visit are returned, unless the present field is deselected.
3. Select region type to be displayed using drop-down list. Select one or more regions, subregions and/or rivers or select a specific site. (Example: select Bioregion using drop-down list, select Fynbos in Bioregion and Berg in River lists).
4. Select a particular month or season, or limit results to a particular type of chemdate (e.g. spot-sample). A specific year and/or chemdate may also be selected.
5. Select a particular Study reference if required.
6. Select particular SASS Scores if required. The type of operator can be chosen ("and" , "or"), e.g. SASS4 Score>140 and ASPT>7.5 versus SASS4 Score>140 or ASPT>7.5
7. Unselect Excel PivotTable
8. Select present or absent taxa
9. Run query

1. Select chemical variables

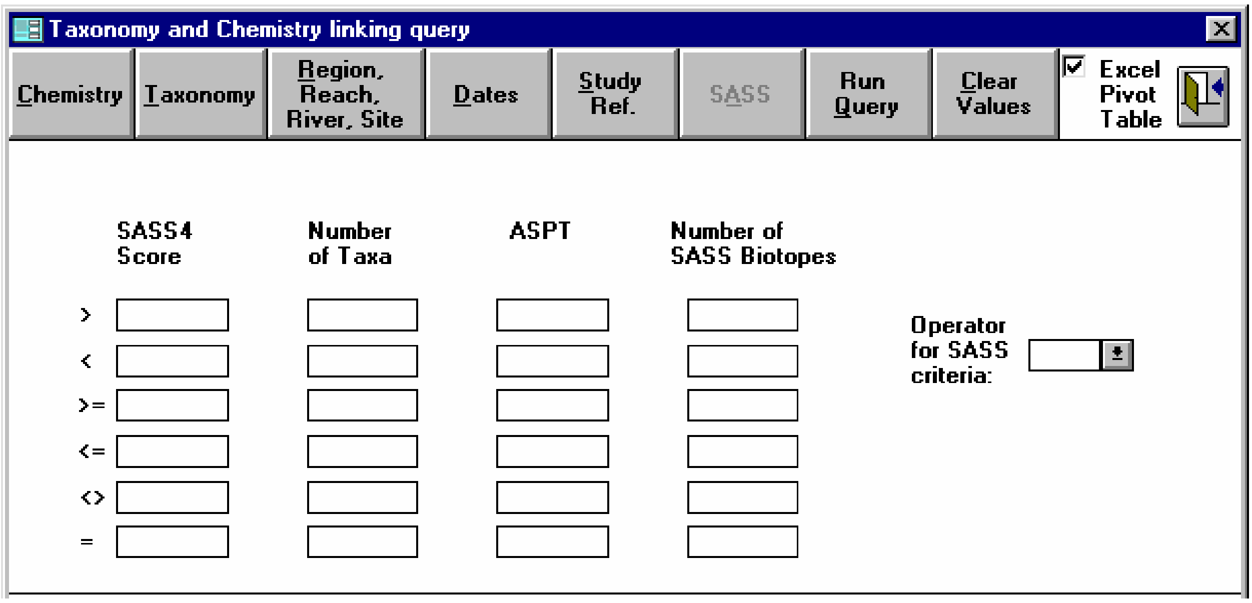


2. Select taxonomic group



3. Select a region, subregion, river and/or site, date and study reference as before

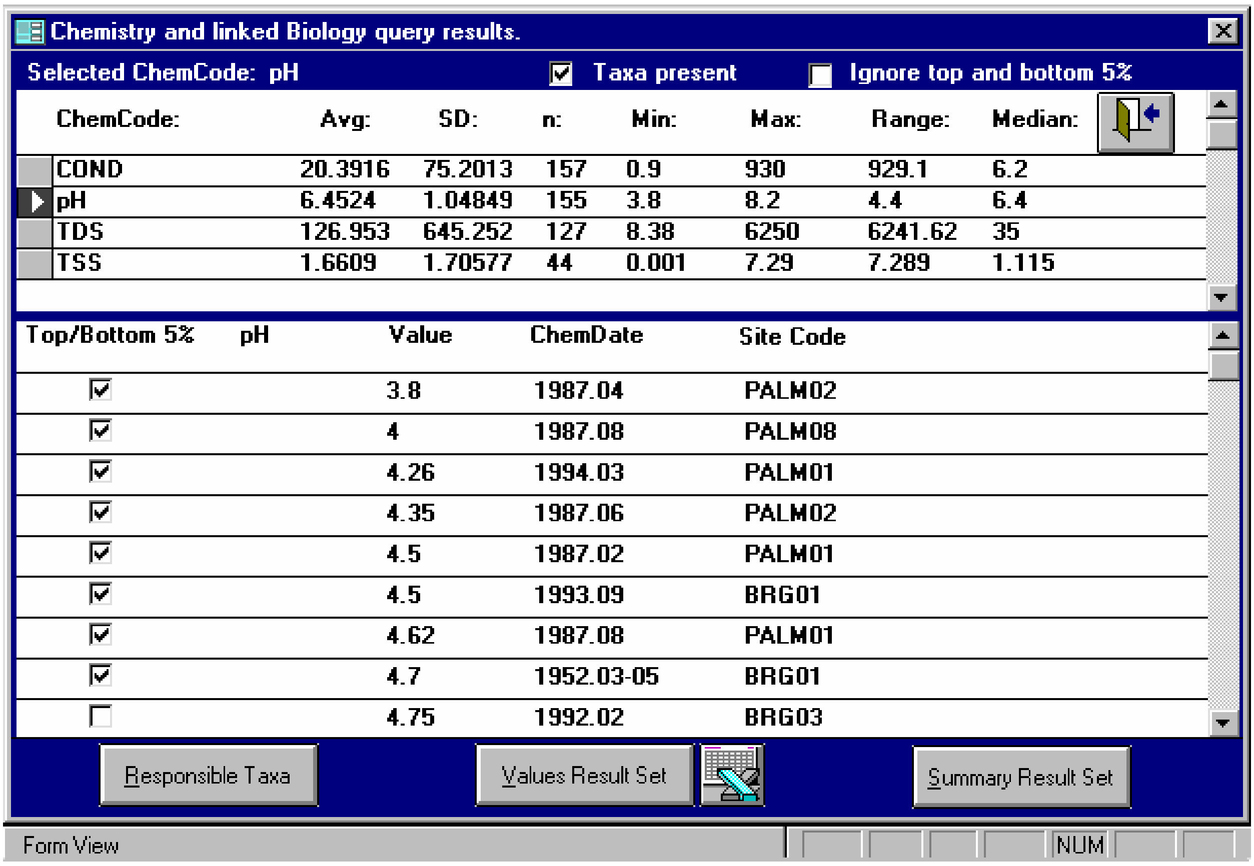
4. Select SASS Scores (SASS4 Score, Number of Taxa or ASPT) and number of SASS biotopes



Results of "chemical parameters linked to biology" query

The average (Avg), standard deviation (SD), number of records (n), minimum (min), maximum (max), range and median values for each selected chemical variable associated with the selected taxa are returned. Additional features include:

- Detailed data for each variable which can be viewed below the summary data by selecting the appropriate variable.
- The upper and lower 2.5% values can be omitted from the statistical results by clicking the "Ignore top and bottom 2.5%". Those values that are excluded are indicated in the Top/Bottom 2.5% column.
- The "Values Result Set" gives a datasheet of all values used in the analyses, including information on the sitecode, chemdate, bioregion, subregion, and latitude and longitude co-ordinates.
- The "Summary Result Set" is a datasheet summary of the statistical results for the selected chemical variables.
- "Responsible Taxa" is a datasheet of all taxa used in the analyses, including information on the presence/absence, abundance, sitecode, chemdate, bioregion, subregion, and latitude and longitude co-ordinates.
- Normal manipulation of data within the datasheets is possible and data may be exported or printed to most spreadsheet packages.
- To exit, select File/Close on Microsoft Access menu.



3.5 Selecting criteria and running queries in Excel PivotTables

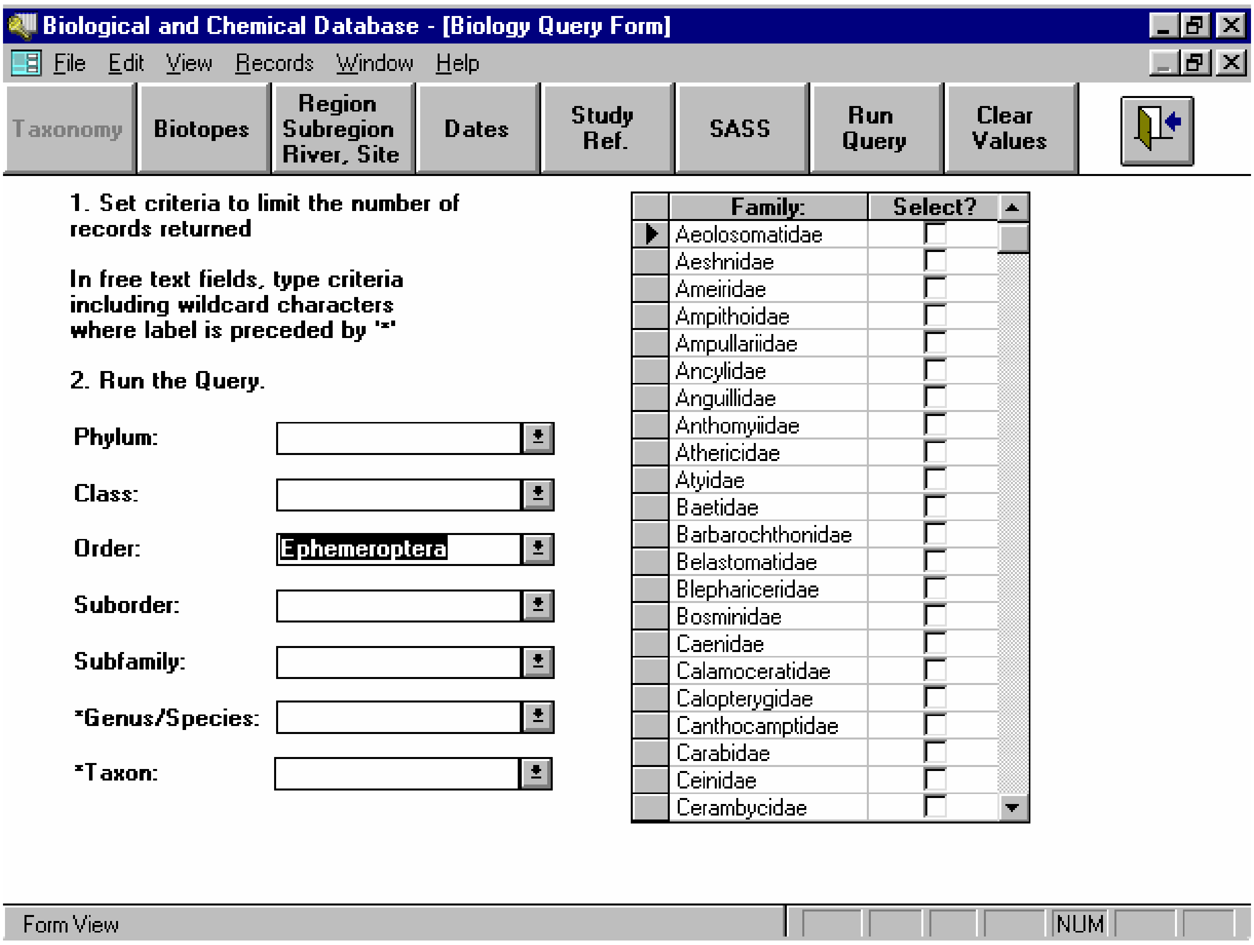
Selection of parameters may be made within Access and/or data may be manipulated within Excel using PivotTables. The following section provides an overview of some of the more common needs of PivotTable users. By default all three pre-defined query frameworks produce PivotTables. The following section outlines the procedure for querying using PivotTables and uses the Biology query as an example.

3.5.1 PivotTable queries: biology

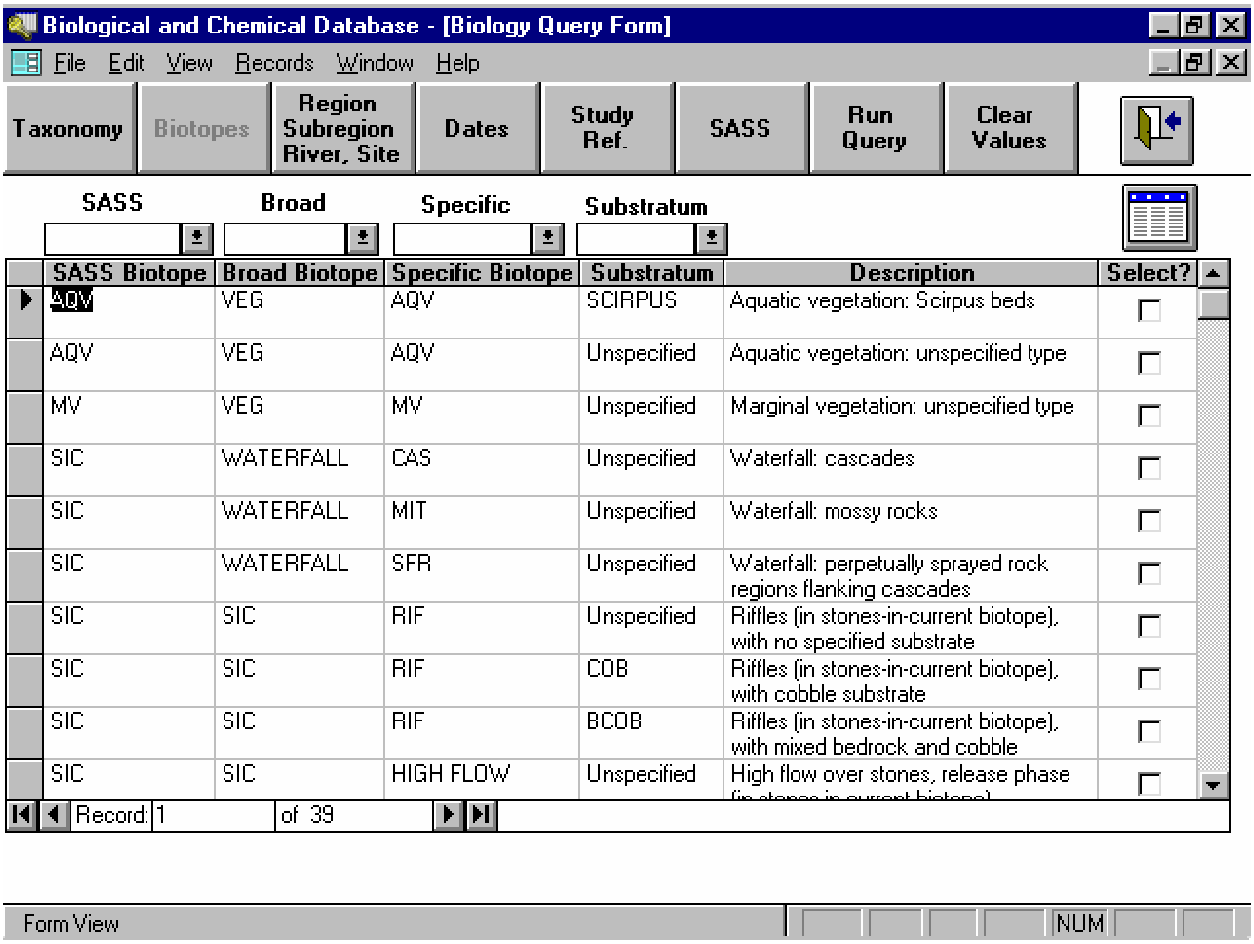
1. Select taxonomic group(s) using drop-down lists and/or selection boxes (e.g. select order Ephemeroptera).
2. Select biotopes (SASS, broad and/or specific) and/or substratum using drop-down lists and clicking the selection boxes. Select all by clicking the "Show all" button.
3. Select region, subregion, river and/or site (as with previous queries)
4. Select date(s) (as with previous queries)
5. Select study reference (as with previous queries)
6. Run query

Note: The fewer specifications made in Access the more time-consuming the query, although there is greater flexibility when in the PivotTable. By default both present and absent taxa are returned.

1. Select taxonomic group



2. Select biotopes



Biological and Chemical Database - [Biology Query Form]

File Edit View Records Window Help

Taxonomy | Biotopes | Region Subregion River, Site | Dates | Study Ref. | SASS | Run Query | Clear Values

SASS | Broad | Specific | Substratum

SASS Biotope	Broad Biotope	Specific Biotope	Substratum	Description	Select?
AQV	VEG	AQV	SCIRPUS	Aquatic vegetation: Scirpus beds	
AQV	VEG	AQV	Unspecified	Aquatic vegetation: unspecified type	
MV	VEG	MV	Unspecified	Marginal vegetation: unspecified type	
SIC	WATERFALL	CAS	Unspecified	Waterfall: cascades	
SIC	WATERFALL	MIT	Unspecified	Waterfall: mossy rocks	
SIC	WATERFALL	SFR	Unspecified	Waterfall: perpetually sprayed rock regions flanking cascades	
SIC	SIC	RIF	Unspecified	Riffles (in stones-in-current biotope), with no specified substrate	
SIC	SIC	RIF	COB	Riffles (in stones-in-current biotope), with cobble substrate	
SIC	SIC	RIF	BCOB	Riffles (in stones-in-current biotope), with mixed bedrock and cobble	
SIC	SIC	HIGH FLOW	Unspecified	High flow over stones, release phase	

Record: 1 of 39

Form View NUM

3. Select region, subregion, river or site, date, study reference and SASS Scores as before.

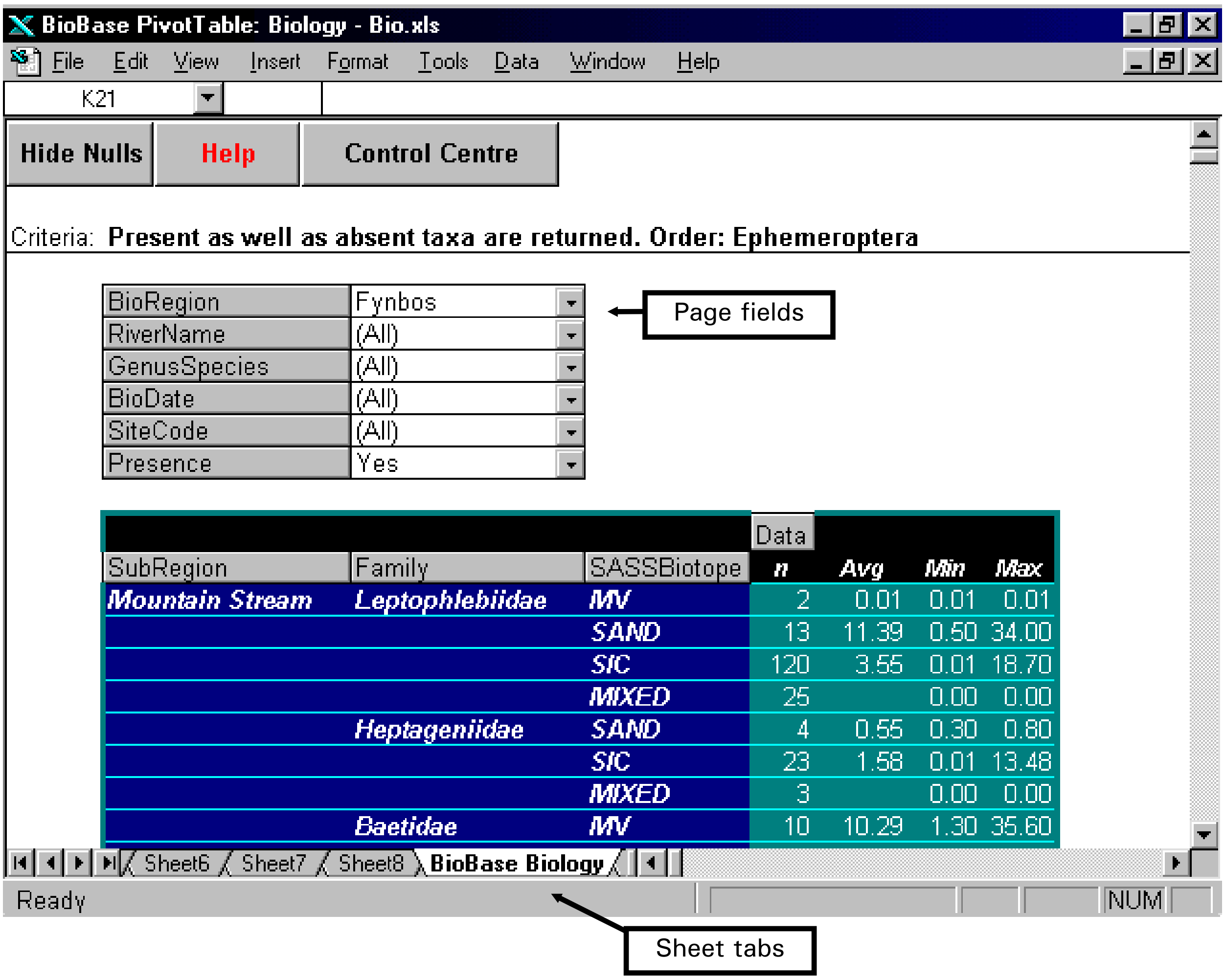
Results of the biology query

The user is automatically switched to the Excel PivotTables that have been designed to facilitate data manipulation and analysis. The PivotTables may be modified by adding or deleting Page Fields, adding, deleting or modifying Data Fields and by rearranging the layout of the PivotTable. Summary Help Tables (click on + to expand and - to reduce individual points) have been included to assist in the basic manipulation of the data, and the more common sequences are outlined in section 3.5.2. Once a PivotTable has been streamlined for the user's particular requirements it may be saved permanently as a new PivotTable using File/Save As.
NB: If the data in the database is modified or updated, querying needs to be re-done via the Query Centre or erroneous values will result.

1. **Page Fields** control the detail and way in which data are viewed. The drop-down lists above the data may be used to select a specific region, subregion, river, site, biotope etc. or be added to the data as a column or row selector. To add a new page field, right click on the lists and select "PivotTable". Select the required page field from the list of Available Page Fields and

drag to Selected Page Fields on the left. Similarly to remove a page field drag from Selected Page Fields to Available Page Fields on the right. Click on finish to return to PivotTable. Dragging a page field to the data creates a field item that is a column or row of the appropriate page field (e.g. Subregion, Family, SASS Biotope) (see PivotTable Wizard).

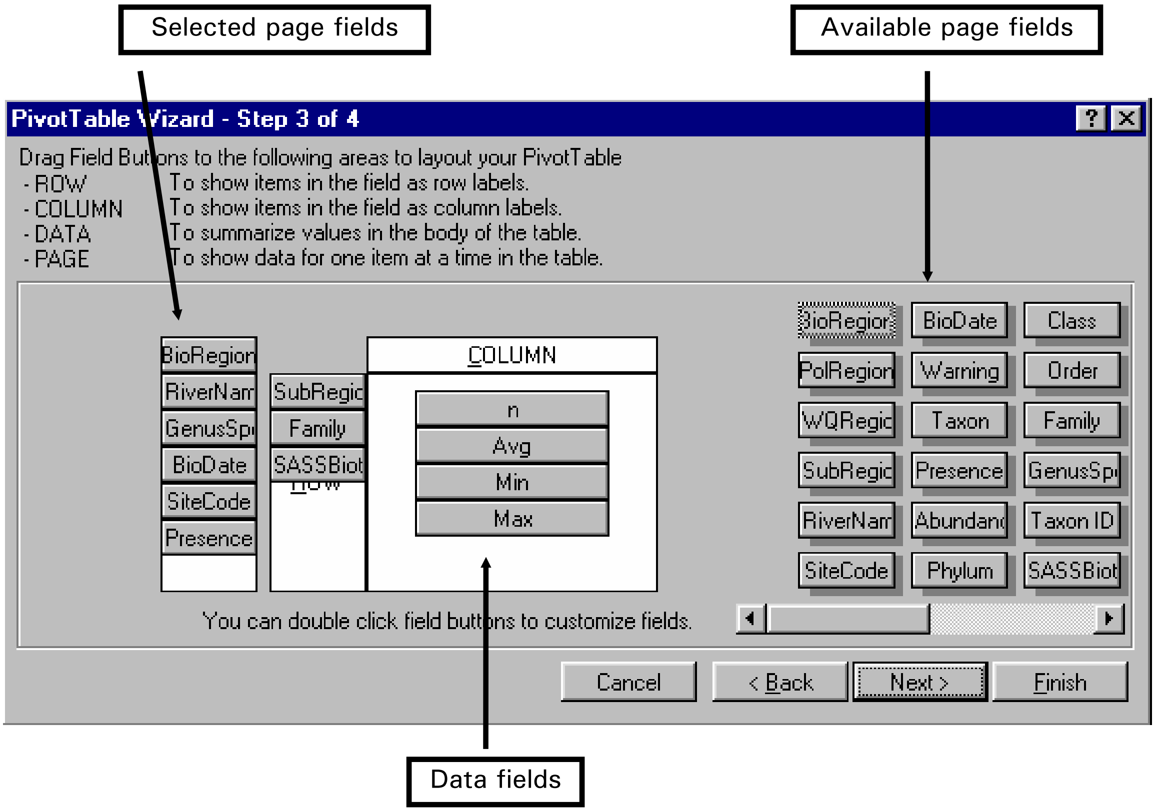
Biobase Biology PivotTable



2. **Data Fields** refer to the actual data and are normally reported as an abundance value such as average, minimum, maximum etc. To change or format data fields, right-click on the data and select "PivotTable". Select from Available Page Fields and drag to the data section. Double click to specify the format of data e.g minimum, average, count etc. and rename data field appropriately. The number of decimal places is specified using the number button. Select finish to return to PivotTable.

3. To view the **underlying data,** double click on the relevant data field (e.g. double-click on 1.88 in Avg Abundance column to view 76 taxa responsible for abundance). Other information such as taxonomic grouping, region, subregion, biotope, dates, co-ordinates, etc. are displayed. Normal manipulation of data within the datasheets is possible and data may be exported or printed. To return to the Biology Query, select the Biobase Biology sheets at the bottom of the PivotTable.

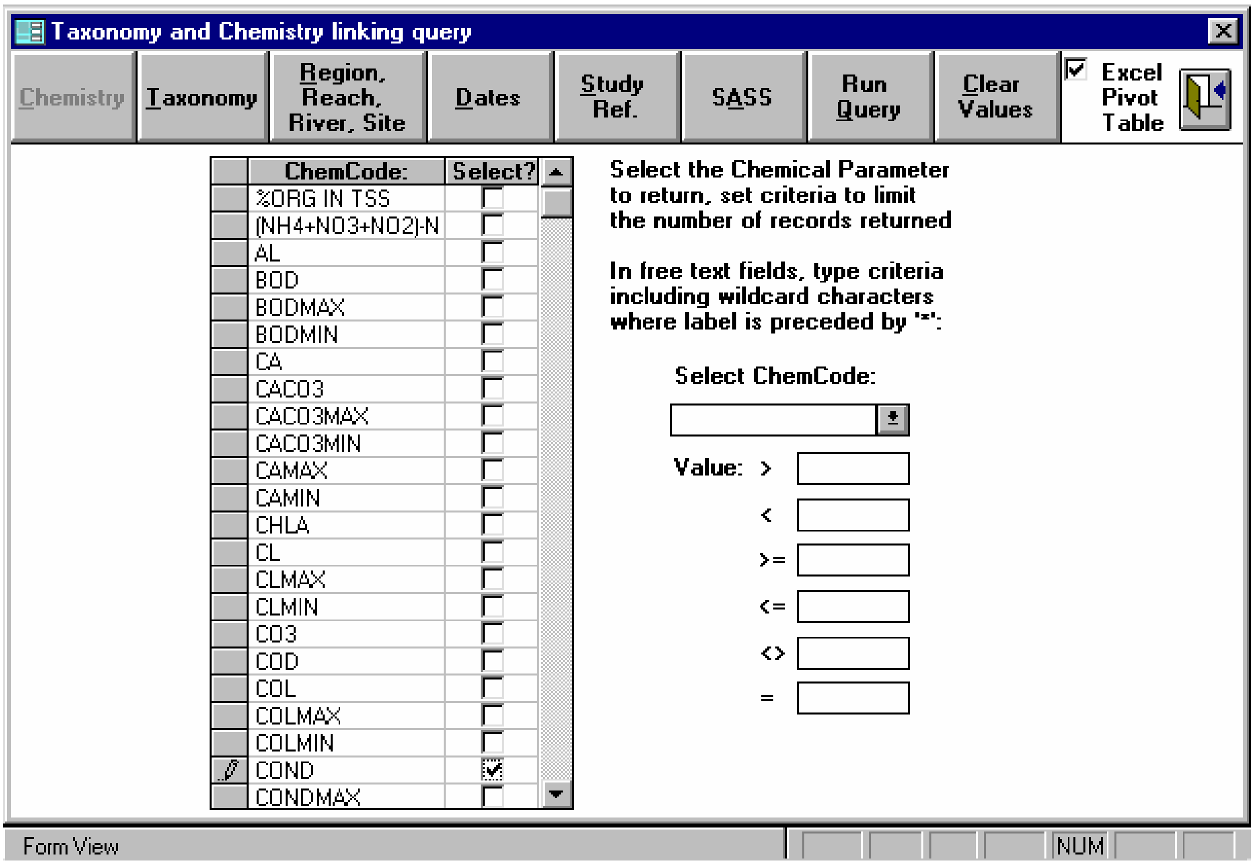
PivotTable Wizard



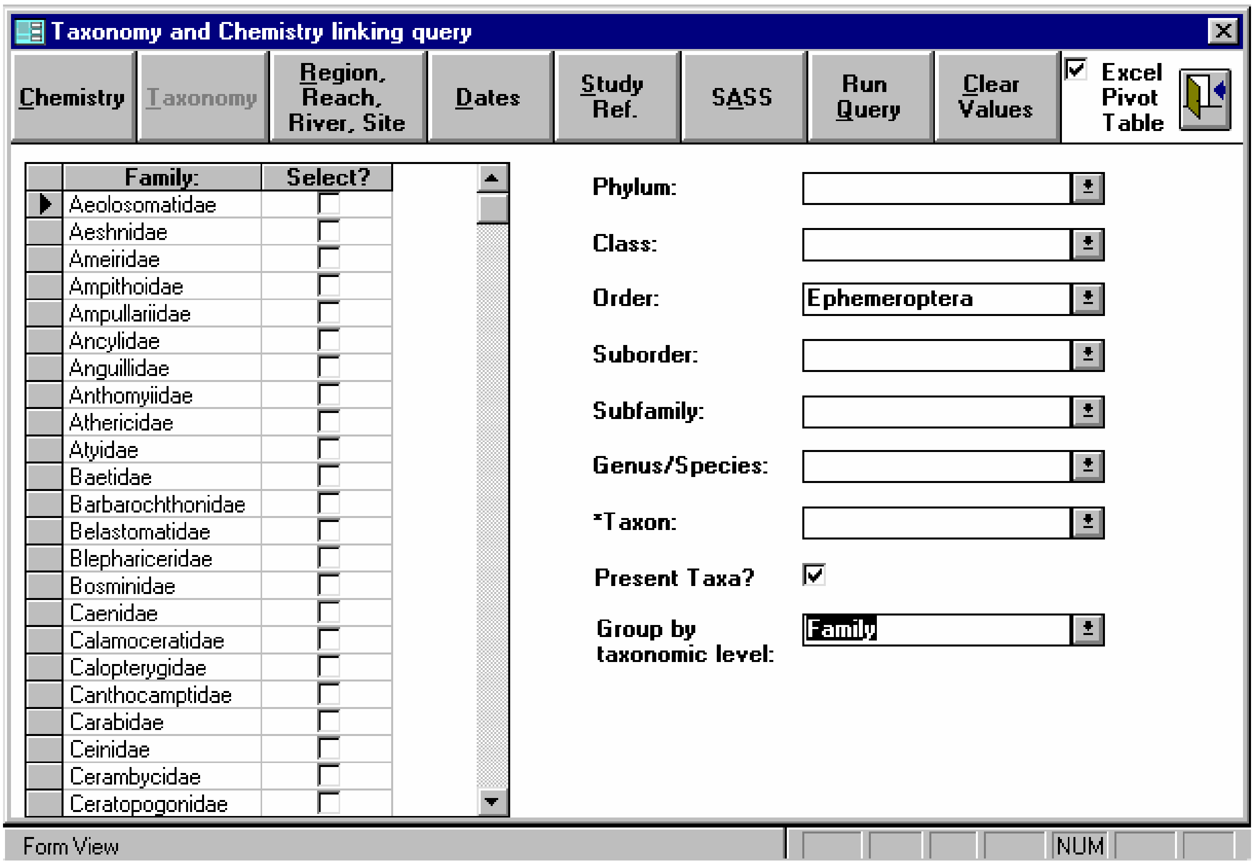
3.5.2 PivotTable queries: chemical parameters linked to biology

1. Select chemistry variables by clicking boxes or using drop-down lists and range buttons.
2. Select taxonomic group(s) using drop-down lists and/or selection boxes (e.g. select order Ephemeroptera). For calculating ranges for specific groups e.g. families, it is important to use "Group by Taxonomic Level", so that multiple records for the family are not returned and n, average, minimum, maximum, etc. values for the selected chemical parameters are correct.
3. Select region, subregion, river and/or site (as with previous queries).
4. Select date(s) (as with previous queries).
5. Select study reference (as with previous queries).
6. Run query.

1. Select chemical parameters

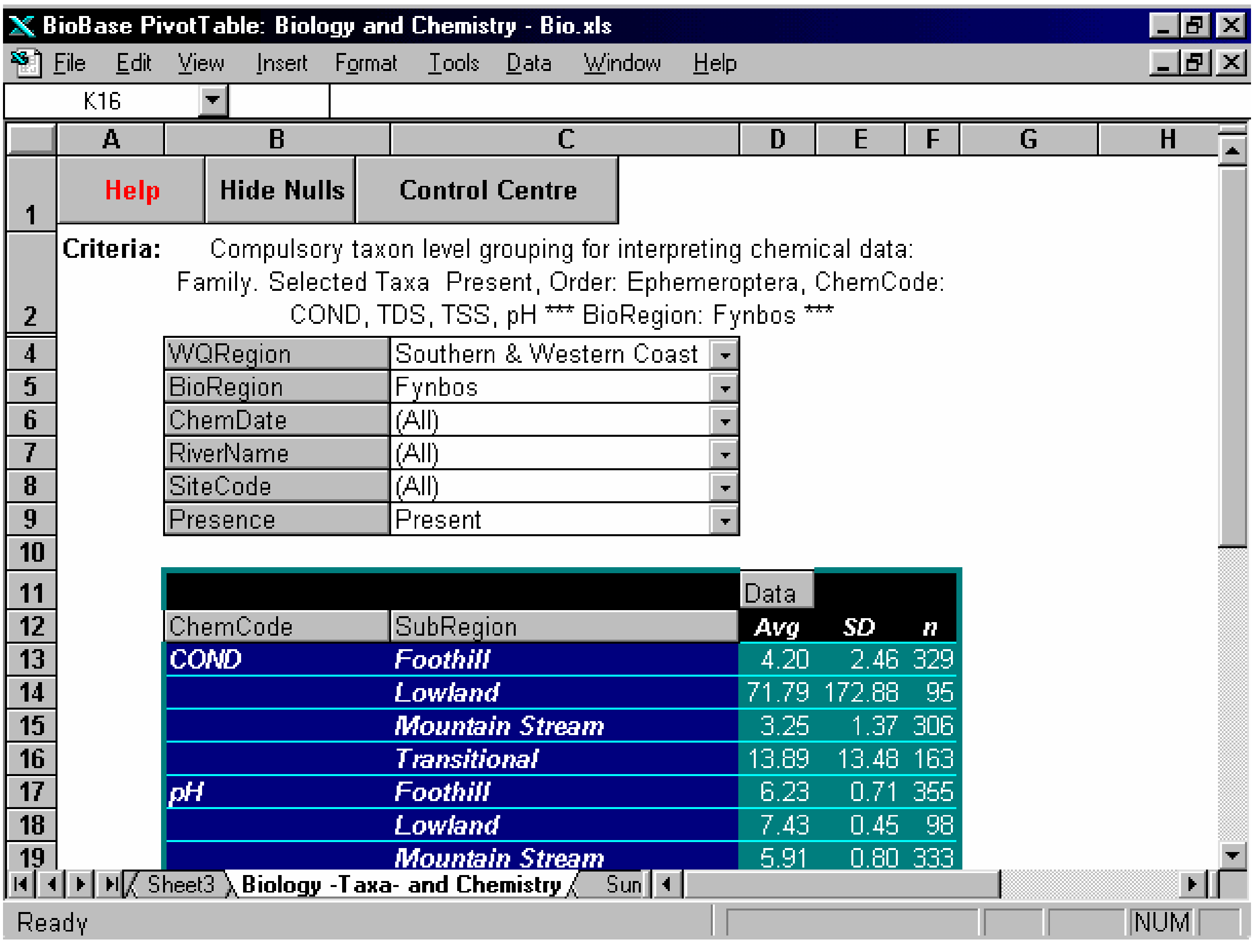


2. Select taxonomic group(s)



3. Select region, subregion, river or site, date, study reference and SASS Scores as before.

The PivotTable returned has exactly the same functionality as that of the biology query. Similarly the chemistry query may also be manipulated and analysed using a PivotTable format.



3.5.3 Additional functionality of PivotTables

1. To hide #DIV/O!, select "Hide Nulls" button.

2. *To show or hide detail data in a PivotTable,* select the field item whose row or column detail you want to show or hide, right-click and select Group And Outline, and then Show Detail or Hide Detail. Note: If you want to show or hide detail items for specific data in the data area, double-click the data item. The detail data is placed on a separate worksheet in the workbook. If you double-click an item that has no detail data, you can add a row field.

3. *To show or hide grand totals in a PivotTable,* select a cell in the PivotTable, right-click and select PivotTable, click Next. To display grand totals, select the Grand Totals For Columns check box, the Grand Totals For Rows check box, or both. To hide grand totals, clear the Grand Totals For Columns check box, the Grand Totals For Rows check box, or both. Note: The default summary function used to calculate the grand totals is also used to calculate values for the associated data field.

4. *To sort PivotTable items by labels,* select the button for the field you want to sort, on the Data menu, click sort. Tip: Field items in a PivotTable are automatically sorted in ascending order, according to their labels. If you later move or sort the items, you can restore their original order by sorting them by their labels.

5. *To display page field pages on a separate worksheet*, select a cell in the PivotTable, right-click the mouse button, and then click Show Pages. Click the page field that contains the items you want to display on separate worksheets.

6. *To delete sheets*, position cursor on sheet tab to be deleted, right-click the mouse and select delete/OK.

7. *To create a chart* from a PivotTable using data from your worksheet, select the entire PivotTable, including the column fields and row fields. Do not include grand totals or page fields in your selection. You can also create a chart from a PivotTable with page fields.

- Start the Chart wizard (Insert Chart)
- Drag across the worksheet until the rectangle encompasses the area you want for the chart.
- Follow the instructions in the Chart Wizard.
- Notes: Microsoft Excel creates a chart that reflects the multiple levels of data in the PivotTable. Your chart changes when you hide items, show details, or rearrange fields in the PivotTable.

3.6 Create your own queries: "Saved-User Queries"

Specific queries can be created within Access using traditional Access tools. All have the prefix "Biobase".

How to run a Saved-User Query

1. Click the Query Centre button on the Control Centre menu.
2. Click the Saved User Queries button.
3. If your query does not appear, click the "Update this list" button.

4. Select the query you want to run and click on the “Run Query” button.
5. Click “Yes” button to confirm or “No” to cancel.
6. The datasheet will be displayed.

Creating a Saved-User Query

1. Click the Query Centre button on the Control Centre menu.
2. Click the Saved User queries button.
3. Select New Query (confirm New Query).
4. Add appropriate tables by double clicking.
5. Drag required fields into the query design table and run query.
6. The datasheet will be displayed.

Note: Queries depend on the relationships between tables.

3.7 More efficient system usage

Access forms

- A form in Access provides a way of interacting with the underlying database tables. A form may consist of several pages (All referring to the same underlying record). This is the case especially when not all controls/fields could be fitted onto one screen.
- Moving between the different fields is controlled by the buttons in the top left-hand corner of the screen. They indicate on which page of the form you are, because the appropriate button is greyed out, and not available to click on.
- In the top right corner, a button (with a little door, and a blue arrow pointing 'out') is always available to close the form. This returns you to whatever other form was active previously.
- The form may be printed by choosing File|Print from the normal Access menu. This is not recommended, as the form prints as it is presented on screen (i.e. black backgrounds will print using vast quantities of toner).

Using the keyboard efficiently

- One can often switch between fields using the tab key, rather than clicking on fields using the mouse.
- Whenever a button has an underlined letter, it can be accessed, by pressing ALT and the appropriate letter on the keyboard (e.g. switching between different pages of a form).
- In some cases the current field can be undone by hitting the Esc key. Hitting the Esc key again, causes the current record to be undone.

Using drop-down lists efficiently

- To see what options are available click on the drop-down button of the field, or alternatively tab into the field, or click in it with the mouse, and start typing. Hitting the F4 key also shows all available options.
- The list automatically selects an entry, quickly narrowing down to the appropriate choice as more characters are typed. To make a final selection either tab out of the field, hit the enter key, or click on the selection with the mouse.
- If the list does not contain a desired entry, it can be added by double-clicking in the field. This action takes you to a form, where the new entry may be added (click on the “Add New” button to rapidly move to a new record). On closing the form, the new entry becomes available in the drop-down list.

- In many cases to enable rapid location of particular records, drop-down lists are provided to find a particular record. It is important to distinguish these drop-down lists (which are clearly labelled with the words such as Go to", or "Find"), from those used to fill in a field. In addition, in-built search functionality is provided within MS Access (press Ctrl-F in most fields).

General buttons

- Exit button - close the form, and return to the previous form used.
- Add New button - if a new record is to be added.

Subforms

Many records are displayed pertaining to a particular category, or selected record, e.g. the many biotopes for a specific site visit, are displayed in a "subform". Whenever a different record (e.g. biotope) in such a subform is selected (by clicking on any field of that record), the position of the record selector changes, indicating which the present record is. Any such record can be deleted, by clicking on the record selector, and pressing the "Delete" button on the computer keyboard.

Moving between windows

Different forms may be open at the same time. You can switch between them, by clicking on the Windows menu item, and clicking on the appropriate window's description in the list at the bottom of the menu. The more forms you have open, the more memory is used up, and generally this results in slower performance.

To add a new record

Never overtype any existing field contents, in most cases go to the last record, and move one beyond, to obtain a clean, new record. Or, if such a facility is available, click "Add New" button.

Checkboxes

You can toggle between yes and no, by pressing the spacebar while the checkbox has the focus.

4. USES AND POTENTIAL PROBLEMS OF THE DATABASE

4.1 Deducing safe ranges of different water quality variables, for different species

Deducing water quality ranges was the purpose for which the database was originally designed. It was hoped that, by means of correlation analyses, we would be able to draw conclusions about the biogeographical ranges of different species, relative to water quality variables. Inadequacies in the data, such as uneven temporal and geographic coverage, problems of incompatibility of some measurements, and a lack of consistency in the range and thoroughness of chemical measurements, meant, however, that any reliable correlation analyses were unlikely to be forthcoming. Fortunately, at this time it was decided by DWAF that guidelines should be produced, as opposed to the rating curves for which the correlations were intended. Assisting with the production of guidelines lies more within the scope of the database, since it can provide descriptive information as to which biological species are found where, and under what conditions. Such information has not yet been extracted. Instead, an example is provided of the kinds of results which simple queries of water chemistry and biological data may produce (see Table 4.1).

Table 4.1. Summary of results obtained from queries run on three invertebrate families, to discover the recorded ranges of pH (PH), conductivity (COND) and sulphate concentration (SO4) (River names shown in brackets after values).

	Family queried, and its allocated SASS score (shown in brackets)		
Chemical variables queried :	**Ephemerellidae** (15)	**Heptageniidae** (10)	**Chironomidae** (2)
PH : Total pH range recorded for all families in database	2.9 (Klip R.) - 9.73 (Umbilo R.)		
Recorded pH ranges at which specific family found	4.7 (Berg R.) - 7.9 (Olifants R.)	4.7 (Berg R.) - 9.2 (Sabie R.)	2.9 (Klip R.) - 9.6(Great Fish R.)
Proportion of records of this family for which pH readings taken	$^{285}/_{301}$	$^{168}/_{209}$	$^{3888}/_{4960}$
COND (mS m^{-1}) : Total range recorded for all families in database	0.92 (Umvoti R.) - 2626.7 (Olifants R.)		
Recorded conductivity ranges at which specific family found	0.95 (Berg R.) - 61.57 (Olifants R.)	1.08 (Berg R.) - 226.8 (Ingane R.)	0.92 (Umvoti R.) - 930 (Zotcha R.)
Proportion of records of this family for which conductivity readings taken	$^{265}/_{301}$	$^{194}/_{209}$	$^{4532}/_{4960}$
SO4 (mg ℓ^{-1}) : Total range recorded for all families in database	0.14 (Molenaars R.) - 2190 (Sundays R.)		
Recorded sulphate ranges at which specific family found	0.3 (Doring R.) - 17.3 (Olifants R.) (1 value of 268 recorded for Groot R.)	0.3 (Doring R.) - 750 (Zotsha R.)	0.4 (Polela R.) - 2112 (Sundays R)
Proportion of records of this family for which sulphate analyses conducted	$^{36}/_{301}$	$^{108}/_{209}$	$^{4051}/_{4960}$

Table 4.1 summarises the results obtained from a query of three invertebrate groups known to be, in order of appearance in the table, very intolerant, fairly intolerant and highly tolerant of extreme water quality conditions, respectively. The query was run at family level, to discover the ranges of conductivity, pH and sulphate ions at which they have been recorded as present (abundance>0). There are, however, a number of problems inherent in such a manipulation. Most of these are concerned with difficulties with the data themselves. Of particular significance is the fact that any

apparent range of a particular chemical variable associated with a species or family, is only the *recorded* range at which the particular group of organisms has been found. It cannot be used as a measure of actual tolerance ranges, since these organisms may well survive in conditions outside of these ranges, but such zones have either never been sampled, or the animals, while they may never have been exposed to those ranges in natural systems, would nonetheless be quite capable of surviving there. Thus if the recorded ranges are used to gauge tolerance, the values obtained will probably err on the conservative side. Of greater importance is the fact that any antagonistic or synergistic effects of combinations of different levels of variables are not taken into account. In particular, the data cannot provide any satisfactory indication of cause and effect in terms of water quality variables and species distribution. Firstly, they are unable to give any indication of the extent of natural geographic variations in the distribution of a species. Secondly, the true cause of a sudden change in species presence, particularly up and downstream of a certain site, may be due to an event such as an oil spill, which is not recorded in the database but which will, nonetheless, have a profound effect on biotic communities. This problem can, to some extent, be circumvented by including such details in the site descriptions. The onus is then on the user to exercise both caution and discretion in interpreting the results provided by an interrogation of the database. Unfortunately however, such information is not always available in the literature. At times, for example, critical chemical variables have not been measured by the researchers. Trace metals may fall into this category, since they are expensive to analyse.

Yet another problem involved in using the database to make statements regarding the tolerance ranges of different suites of organisms to particular conditions is that it fails to incorporate any temporal element of exposure, into such interpretations. Samples of both water quality, and biota, represent "snapshot" or instantaneous pictures of an ecosystem, and the mere fact that a species appears to be present under certain conditions does not mean that it is unaffected in the long term by such conditions. Water conditions at that time may indicate short-term "flushes" of a certain variable; a recent change to which the biota have not yet responded; a past effect from which they have not yet recovered; or a condition under which they really feel no ill effects at all.

Thus, although the database is a useful source of information regarding the recorded tolerance ranges of different taxa to different variables, it is fraught with problems. Used in conjunction with other systems, such as laboratory toxicity tests and the regional chemical database, it can however make a potentially valuable contribution.

4. 2 Assessing changes in community structure, using historical records

The true strength of the database probably lies in this area, for it provides an excellent record of biological and water quality conditions at particular sites, at specific times in the past. In some cases, these records reflect conditions as close to pristine as we are ever likely to record. Pristine or not, they do provide a means of tracking community and water quality changes over time. The Berg River dataset is a good example of this. Data from 1951 to 1953 are available for comparison with those of 1978, as well as of 1992 and 1993.

Some potential pitfalls ought to be brought to the attention of would-be users. The chief of these is that sampling and analytical methods are not always directly comparable in different studies, particularly those that are separated by long periods of time, during which technical innovations have been made. In addition, as has already been mentioned in section 2.2.2., the taxonomy of many species is subject to frequent changes. Both these problems have been tackled as far as possible in setting up this database, and it is hoped that they will not pose too great a difficulty. Users should, however, be aware of their existence.

4.3 Verifying and fine-tuning SASS scores

The records of species composition at sites of different water quality may prove a useful method of assessing the validity of some of the scores allocated to different families used in the SASS scoring system. The data extracted and summarised in Table 4.1 provides an example of this. Here, the families interrogated represent both high (15) and low (2) scoring groups. The known tolerance ranges of such families, as indicated by the database records, provide some means of evaluating the validity of these scores. Families that appear to have very wide tolerance ranges for certain water quality variables should not be allocated high scores. It is also possible that a thorough interrogation of the data may provide clues as to which families may be particularly sensitive to certain types of water pollution, and thus be potential "indicator" taxa of these conditions. All these uses are, of course, subject to the same limitations as those outlined in section 4.1. There is, however, a particular advantage to interrogating the database at the family level required by SASS, as opposed to that of the species. That is, while many of the specimens are undefined or suspect at the species level, identifications are often much more reliable at the level of family.

4.4 Biotope preferences of specific taxa

It has often been observed that certain taxa are more commonly found in one biotope than another. This has seldom, however, been shown quantitatively. It is hoped that an analysis of species found in different biotopes will give some indication of their biotope preferences. Such information would be of great value, for example when allocating SASS scores to sites, since biotope availability could then potentially be taken into account quantitatively.

As with all uses of the database, this one is no exception in that it is beset with the problem of data reliability. It has already been mentioned that the naming of biotopes is frequently haphazard and inconsistent from author to author. Interrogations become most meaningful at positions high up on the hierarchy (i.e. at the levels of stones-in-current and marginal vegetation, for example). At such levels, however, other information such as details of abundance, become incompatible. These are all problems that must be taken into account when running such analyses.

4.5 Geographical distribution of taxa

The compatibility of *Microsoft Access* with geographical information systems such as PC-ARCINFO means that high quality maps may be produced from records. The exact utility of this may lie in ascertaining geographical regions where rivers have not been sampled, rather than in permitting descriptions of actual species distributions.

4.6 Overall utility of the database

This section has dealt at length with the problems involved in any utilisation of the database records. These problems have not been emphasised to discourage potential users, but because it is essential that they be made clear from the start, so that methods of circumventing some of them may be found, and where this is not possible, that the strengths and weaknesses of any results may be quite evident. It is only in the sure knowledge of these problems, that the data may actually be interrogated with any reliability. Two other issues should also be stressed. Firstly, it would be logistically and financially impossible to obtain a similar set of data today. Secondly, the database includes the only data that reflects historical conditions, and therefore more nearly natural conditions than we have today almost anywhere else in this country.

4.7 Additional recommendations

In establishing this database, one of the problems encountered that was both difficult to resolve, and unnecessary, was that caused by the lack of consistency in the way in which different authors present their data. Frequently, useful data are lost, merely because it cannot be made compatible with others. Thus, one of the more important recommendations to emerge from this area of work is that future biological and chemical collections should conform to the units of measurements laid out in Appendix H (in the case of water quality), and that details of proportional abundance, as well as factors such as biotope type, should be considered. In addition, the actual dates on which both biological and chemical data were collected should be available for reference, where they are not actually presented in published reports.

5. TECHNICAL INFORMATION

The database has been created using *Microsoft Access.97* which is a relational database operating on IBM compatible PCs, in the Windows environment. Querying has been streamlined using *Microsoft Excel 97 SR-1.*

Data are easily exported For further analysis in statistical packages such as Statistica or in geographical information systems (GIS) such as PC-ArcView, since all sites have latitude and longitude co-ordinates associated with them.

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Installation: Hardware and Software requirements

- 486 with a minimum of 16 MB RAM, although the system works much more efficiently on a Pentium with 32 MB RAM
- Microsoft Access 97 or run-time version of Access
- Microsoft Excel 97

List of important files

Files required for *Microsoft Access Database* portion

- BioProg97.mdb (workstation program file)
- BioData.mdb (central data file, to which the workstation programs must link)
- BioPivot.mdb (workstation PivotTable source file)
- *.ldb (Microsoft Access Database record locking files, are created automatically).

Files required for *Microsoft Excel PivotTable Analysis* portion

- Bio.xls (Excel PivotTables for the pure biology, and the biology linked to chemistry queries).
- Chem.xls (Excel PivotTables for the pure chemistry query).
- BioSASS.xls (Excel PivotTables where biological data was converted to appropriate SASS taxa).
- SASSdata.mdb

Database maintenance

It is recommended that the database files BioProg97.mdb and BioData.mdb be compacted and repaired on a regular basis (after having secured a backup copy first!). This is necessary in all cases where the database was not shut down normally (e.g. when a power failure occurs).

Backing up of Data

Regular backups are essential. The most important file is BioData.mdb, as this contains all the data. A backup copy of all the files mentioned above as well, in case of hardware failure, or file corruption. Whenever an update of the program becomes available, a secure copy of the BioProg97.mdb file should be made before overwriting it with the updated BioProg97.mdb file that may have become damaged in transit.

6. REFERENCES

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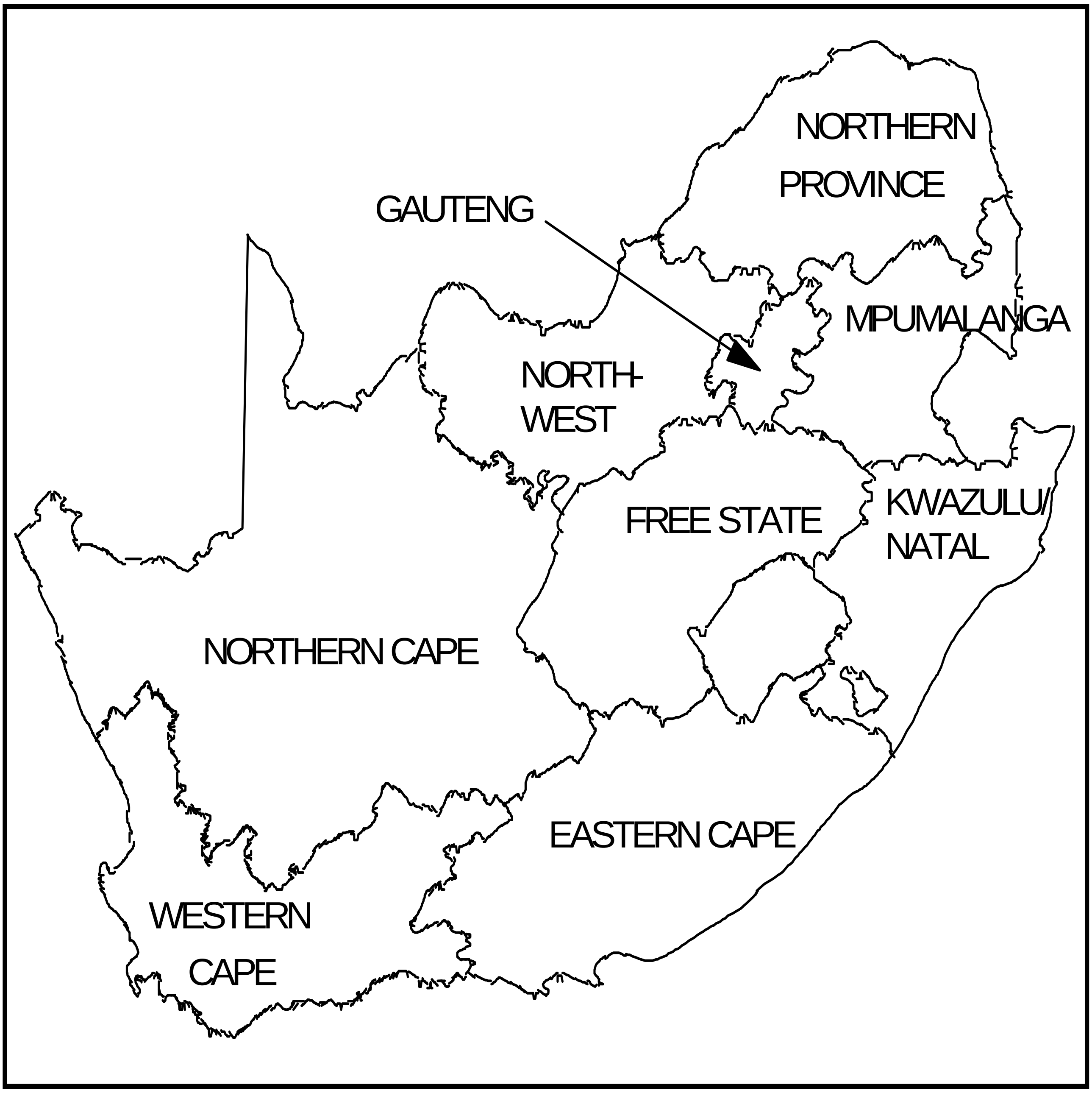
Appendix A. Water Quality Management Regions (after Day *et al.*, in press)

Appendix B. Bioregions (after Brown *et al*., 1996)

Appendix C. Political Regions of South Africa



Appendix D: Bioregions and associated subregions for rivers within South Africa. (Those in parenthesis are bioregions or subregions for which there is no data and those in italics are additional subregions).

Bioregion	Subregion
Limpopa	(Rejuvenated Foothill) Lowland (Gorge)
(Northern Plateau)	(Upland Plateau)
Northern Uplands	Mountain Stream Foothill (Gorge) (Upland Plateau)
(Bushveld Basin)	(Lowland)
Highveld Source	Mountain Stream
Lowveld	Foothill Lowland
Vaal	Source Mountain Stream Foothill/Transitional
Orange	(Foothill) Transitional (Sandbed and Orange) Lowland (Lower Orange A, B, C, D and E)
Arid Interior	Lowland
Fynbos	Source Mountain Stream Foothill Transitional Lowland (Rejuvenated)
Alkaline Interior	*Mountain Stream* Foothill Transitional (Lowland) (Coastal)
Southern Coastal	Mountain Stream *Foothill* *Lowland*
Southern Inland	(Source) Mountain Stream Foothill
Drought Corridor	(Source) Mountain Headwater Foothill Upland Transitional
Eastern Seaboard	Mountain Stream Foothill Transitional Lowland (Coastal) (Gorge and rejuvenated foothill)
Montane	Not assessed
Tugela	Mountain Stream Upland Plateau Lowland (Coastal)
St Lucia Complex	(Upland Plateau) Lowland (St. Lucia Coastal Floodplains) (Maputoland Sandplain)

Appendix E. Hierarchical arrangement of biotope categories giving SASS, broad and specific biotopes, substratum and a description for each. (Blank fields indicted unspecified details).

SASS Biotope	Broad Biotope	Specific Biotope	Substratum	Description of biotope
AQV	VEG	AQV	SCIRPUS	Aquatic vegetation: Scirpus beds
AQV	VEG	AQV		Aquatic vegetation: unspecified type
MV	VEG	MV		Marginal vegetation: unspecified type
SIC	WATERFALL	CAS		Waterfall: cascades
SIC	WATERFALL	MIT		Waterfall: mossy rocks
SIC	WATERFALL	SFR		Waterfall: perpetually sprayed rock regions flanking cascades
SIC	SIC	RIF		Riffles (in stones-in-current biotope), with no specified substrate
SIC	SIC	RIF	COB	Riffles (in stones-in-current biotope), with cobble substrate
SIC	SIC	RIF	BCOB	Riffles (in stones-in-current biotope), with mixed bedrock and cobble substrate
SIC	SIC	HIGH FLOW		High flow over stones, release phase (in stones-in-current biotope)
SIC	SIC	LOW FLOW		Low season trickle over stones, drying phase (in stones-in-current biotope)
SIC	SIC	RIC		Scrapings from large rock in current (in stones-in-current biotope)
SIC	SIC			Stones-in current biotope, specific biotope and substrate unspecified
SIC	SIC	RUN	BED	Run, over bedrock (in stones-in-current biotope)
SIC	SIC	RUN	BCOB	Run, over bedrock/cobble (in stones-in-current biotope)
SIC	SIC	RUN	COB	Run, over cobble (in stones-in-current biotope)
SIC	SIC	RUN	BBOLD	Run, over bedrock/boulder (in stones-in-current biotope)
SIC	SIC	RUN		Run, over unspecified substrate (in stones-in-current biotope)
SIC	SIC	RAPID	BED	Rapid, over bedrock (in stones-in-current biotope)
SIC	SIC	RAPID	BCOB	Rapid, over bedrock/cobble (in stones-in-current biotope)

SASS Biotope	**Broad Biotope**	**Specific Biotope**	**Substratum**	**Description of biotope**
SOOC	SOOC	BACK	COB	Stones-out-of-current, backwater, with cobble substrate
SOOC	SOOC	BACK	GCOB	Stones-out-of-current, backwater, with gravel and cobble mixed substrate
SOOC	SOOC	BACK		Stones-out-of-current, stony bottomed backwater, unspecified substrate
SAND	SAND	BACK	SAND	Stones-out-of-current, sand bottomed backwater
GRAVEL	GRAVEL	RUN	GSAND	Run, over gravel/sand (in stones-in-current biotope)
SAND	SAND	RUN	SAND	Run, over sand (in stones-in-current biotope)
SAND	SAND	BACK	MSAND	Stones-out-of-current, backwater, with mixed mud and sand
SAND	SAND	POOL	SAND	Pool, sand bottom
SAND	SAND	POOL	MSAND	Pool, mixed mud and sand bottom
SOOC	SOOC	POOL	BCOB	Pool, mixed bedrock and cobble bottom
SOOC	SOOC	POOL	BED	Stone bottomed pool, with bedrock substrate specified
MUD	MUD	POOL	MUD	Mud bottomed pool
SOOC	SOOC	POOL		Stone bottomed pool, no substrate specified
SOOC	SOOC	POOL		Pool, with no substrate type specified
SAND	SEDIMENT			Sediment bottom, with no substrate type specified
SAND	SAND		SAND	Sandy substrate, biotope not specified
MIXED	MIXED	SAND AND VEG	SAND AND MV	Mixed biotopes: sand and marginal vegetation, unspecified type
MIXED	MIXED			Mixture of biotopes sampled, and data pooled
SIC	SIC	RUN	FLAT	Stones-in-current, slight to moderate current; smooth flow

Appendix F. Summary of study references used in compiling the biological and chemical database.

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Appendix G. Details of biological and chemical data for each study references

STUDY REFERENCE: 1

RIVER	GREAT BERG RIVER
REFERENCE	HARRISON A.D. & ELSWORTH J.F 1958. HYDROBIOLOGICAL STUDIES OF THE GREAT BERG RIVER, WESTERN CAPE PROVINCE. PART 1. GENERAL DESCRIPTION, CHEMICAL STUDIES AND MAIN FEATURES OF THE FLORA AND FAUNA. TRANSACTIONS OF THE ROYAL SOCIETY OF SOUTH AFRICA. VOL. 35. PART 3. PP.125-226.

BIOLOGICAL DATA

Biotopes sampled:		Sampling devices:
A) stony bottom:	in stickles and runs	Surber sampler or hand net
	in stickle	Surber sampler or hand net
	in cascade/torrent	hand net
	in backwaters	hand net
B) vegetation:	marginal vegetation	hand net
	stream bottom vegetation	hand net
C) sediment:	sandy bottom	Birge-Ekman grab sampler
	muddy bottom	Birge-Ekman grab sampler

Mesh size » 950 μm. All sites were sampled monthly for approximately 1.5 years (May 1951 to December 1952). Animal associations from each biotope were grouped seasonally and are represented as mean percentage per season for the whole sampling period. Spring = September, October, November; Summer = December, January, February; Autumn = March, April, May; Winter = June, July, August. Thirteen sites were sampled.

CHEMICAL DATA

The results of analyses of samples collected monthly over 2.5 years have been grouped together seasonally by year. Mean, minimum and maximum values are frequently given. The following variables are reported:

- temperature (TEMP): mean, minimum and maximum (in °C), measured on a daily basis for all stations except BERG1,13,14,16,18,19, which were measured monthly
- pH (PH), measured using a Beckman pH probe (mean, max and min values given)
- conductivity (COND): measured with a Dionic water tester reading in micromhos. Values converted to mS m^{-1} at 25°C (mean, max and min values given)
- total dissolved solids (TDS), in mg ℓ^{-1} (mean, max and min values given)
- dissolved oxygen % saturation (DOPER) in % (mean values given)
- Biological Oxygen Demand (BOD), 5-day measured in mg ℓ^{-1} (mean values given)
- albuminoid ammonia, equivalent to Kjeldahl nitrogen (J.F. Elsworth, pers. comm.), (KJN) in mg ℓ^{-} (mean values given)
- ammonia nitrogen (NH4-N), in mg ℓ^{-1} (mean values given)
- nitrite (NO2-N), in mg ℓ^{-1} (mean and max values given)
- nitrate (NO3-N), in mg ℓ^{-1} (mean values given)
- phosphate: equivalent to soluble reactive phosphate (SRP), in mg ℓ^{-1} (mean values given)
- total alkalinity (TAL): in mg ℓ^{-1} converted to meq ℓ^{-1} (mean, max and min values given)
- total hardness (CACO3): in mg ℓ^{-1} (mean, max and min values given)
- calcium (CA), magnesium (MG), sulphate (SO_4), silicate (SI), iron (FE): only extreme minimum and maximum values in mg ℓ^{-1} over the whole period were published.
- chloride (CL), and iron (FE): in mg ℓ^{-1}, published as a seasonal mean, minimum and maximum for most sites
- colour (COL): in A.P.H.A. units (mean, max and min values given)
- turbidity (TURB): in mg ℓ^{-1} SiO_2 (mean, max and min values given)

MATCHING BIOLOGICAL AND CHEMICAL DATA

The biological data for each site has been linked with the chemical data collected during the same time period. Since the biological data is not divided into years, there are often more than one set of chemical data per biological data set. The chemical data is recorded per zone and thus each chemical data set may encompass more than one site within each zone.

STUDY REFERENCE: 2

RIVERS	PRINCIPLE RIVERS OF SOUTHERN NATAL (UMKOMAAS RIVER CATCHMENT AND RIVERS SOUTH TO MTAMVUMA)
REFERENCE	KEMP P.H., CHUTTER F.M. & COETZEE D.J. 1976. WATER QUALITY AND ABATEMENT OF POLLUTION IN NATAL RIVERS. PART V. THE RIVERS OF SOUTHERN NATAL. NATIONAL INSTITUTE FOR WATER RESEARCH, CSIR AND THE TOWN AND REGIONAL PLANNING COMMISSION REPORT.

BIOLOGICAL DATA

Biotopes sampled:		Sampling devices:
A) stony bottom:	stone-in-current	Surber sampler or hand net
	stone-out-of-current	hand net
	cascades/waterfall	hand net
B) vegetation:	marginal vegetation	hand net (2-3m sweep)
	aquatic vegetation	hand net
C) sediment:	mixed	corer (5/sample)

Mesh size = 300 μm. All sites were sampled once in June 1972. The number of individuals of each taxon are expressed as a percentage of the total number of animals found in a sample.

CHEMICAL DATA

Water samples for chemical analysis were collected between 1968 and 1971. Values given are the means expressed as rainy and dry season values. The latter is reported in the database as this is the period during which benthic collections were undertaken. The following variables were measured:

- temperature (TEMP), mean (in °C)
- pH (PH)
- conductivity (COND), mS m^{-1}
- total dissolved solids (TDS), mg ℓ^{-1}
- dissolved oxygen, (DO) mg ℓ^{-1}
- dissolved oxygen % saturation (DOPER) in %
- Biological Oxygen Demand (BOD): 5-day measured in mg ℓ^{-1}
- Kjeldahl nitrogen (KJN), in mg ℓ^{-1}
- nitrate (NO3-N), mg ℓ^{-1}
- phosphate, mg ℓ^{-1} assumed equivalent to soluble reactive phosphorus (SRP)
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ converted to meq ℓ^{-1}
- total hardness (CACO3), mg ℓ^{-1} $CaCO_3$
- calcium (CA), magnesium (MG), sulphate (SO_4), sodium, (NA), potassium (K), chloride (CL) and fluoride (F), all in mg ℓ^{-1}
- Free carbonic acid, as mg ℓ^{-1} CO_2 (FREE CO2)

MATCHING BIOLOGICAL AND CHEMICAL DATA

The biological data for each site [sampled in June (WINTER) 1973] has been linked with the chemical data for the dry season.

STUDY REFERENCE: 3

RIVERS	ASSEGAAIBOSCH STREAM, KUILS RIVER, SOUT RIVER
REFERENCE	HARRISON A.D. 1958a. HYDROBIOLOGICAL STUDIES OF THE GREAT BERG RIVER, WESTERN CAPE PROVINCE. PART 2. QUANTITATIVE STUDIES ON SANDY BOTTOMS, NOTES ON TRIBUTARIES AND FURTHER INFORMATION ON THE FAUNA, ARRANGED SYSTEMATICALLY. TRANSACTIONS OF THE ROYAL SOCIETY OF SOUTH AFRICA. VOL. 35. PART 2. PP.227-276.

BIOLOGICAL DATA

River:	Biotopes sampled:	Sampling devices:
Assegaaibosch	stony bottom in stickles (riffle)	hand net

Kuils	stony bottom in stickles (riffle)	hand net
Sout	marginal vegetation	hand net
Berg	mixed biotopes	Surber sampler or handnet

Mesh size » 950 μm

Assegaaibosch: Sampled monthly from June 1950 to August 1951. Animal associations were grouped seasonally and are represented as mean percentage per season for the whole sampling period. Spring = September, October, November; Summer = December, January, February; Autumn = March, April May; Winter = June, July, August.

Kuils: Temporary stream, sampled in October 1950, April (four weeks after it started flowing), July, October and November 1951 (afterwhich it dried up).

Sout: Temporary stream, sampled in April (three weeks after it started flowing), June, August and October 1951 (afterwhich it dried up).

Berg: Sampling as described in reference 1, since these data (which refer only to simuliid abundance) were obtained during the course of this study.

CHEMICAL DATA
Assegaaibosch: Water in this tributary was very similar to that at site 1 on the main Berg River (see study reference 1). Only temperature (^{0}C), pH and TDS (in mg ℓ^{-1}) are published. All values were one-off measurements.
Kuils & Sout: All values were one-off measurements taken on a single day. The following variables were measured:

- temperature (in °C)
- pH (measured using a Beckman pH probe)
- conductivity (measured with a Dionic water tester reading in micromhos, values converted to mS m^{-1} at 25°C)
- total dissolved solids (TDS) (in mg ℓ^{-1})
- total alkalinity (TAL), as $CaCO_3$ in mg ℓ^{-1} and converted to meq ℓ^{-1})
- total hardness (CACO3), (as $CaCo_3$ in mg ℓ^{-1})
- sulphate (SO4), chloride (CL) and turbidity (TURB) (mg ℓ^{-1} SiO_2)

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological data for each site is linked with the chemical data collected during the same time period.

STUDY REFERENCE: 4

RIVERS	CROCODILE, SABIE, OLIFANTS, LETABA, LUVUVHU AND MUTALE RIVERS IN THE KRUGER NATIONAL PARK, EASTERN TRANSVAAL.
REFERENCE	MOORE C.A. & CHUTTER F.M. 1988. A SURVEY OF THE CONSERVATION STATUS AND BENTHIC BIOTA OF THE MAJOR RIVERS OF THE KRUGER NATIONAL PARK. CSIR AND NIWR CONTRACT REPORT, PRETORIA.

BIOLOGICAL DATA

Biotopes sampled:		Sampling devices:
A) stony bottom:	stone-in-current (riffle)	hand net (kick sampling)
	stone-out-of-current	hand net (kick sampling)
B) vegetation:	marginal, trailing and emergent vegetation sampled together	hand net
C) sediment:	including diatom growth on rocks and sand, fine sediment on sand or bedrock, and sand	hand net

Mesh size = 300 μm. Sampling months varied between sites, but generally included all or some of the following months: April 1985, June 1985, September 1985, November 1985, January 1986, April 1986, June 1986, August 1986 and October 1986.

CHEMICAL DATA
Chemical data was collected by the Hydrological Research Institute at their routine monitoring sites from October 1983 to October 1986. Mean values were calculated for each monitoring site and were expressed by season: dry winter (April to September) and wet summer (October to March). The following variables were reported:

- pH (PH)
- conductivity (COND), mS m^{-1}
- total dissolved solids (TDS), mg ℓ^{-1}
- total hardness (CACO3), mg ℓ^{-1} $CaCO_3$
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ and converted to meq ℓ^{-1}
- Kjeldahl nitrogen (KJN), in mg ℓ^{-1}
- nitrate + nitrite (NO2+NO3), mg ℓ^{-1}
- total phosphorous (TOT-P), mg ℓ^{-1}
- total dissolved phosphorous (SRP), mg ℓ^{-1}
- ammonium (NH4-N), in mg ℓ^{-1}
- calcium (CA), magnesium (MG), sulphate (SO4), sodium, (NA), potassium (K), chloride (CL) and fluoride (F), silica (SI); all in mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Using the latitude and longitude co-ordinates biological sites were matched with HRI chemical sites. Biological dates were linked with the appropriate winter or summer season chemical date.

STUDY REFERENCE: 5

RIVERS	JUKSKEI-CROCODILE RIVER SYSTEM
REFERENCE	WILKINSON R.C. 1979. THE INDICATOR VALUE OF THE STONES-IN-CURRENT FAUNA OF THE JUKSKEI-CROCODILE RIVER SYSTEM, TRANSVAAL, SOUTH AFRICA. UNPUBLISHED M.SC. THESIS, UNIVERSITY OF PRETORIA, SOUTH AFRICA.

BIOLOGICAL DATA

Biotope sampled:		Sampling device:
A) stony bottom:	stone-in-current	Surber sampler

Mesh size = 250 μm. 18 sites were sampled monthly from March 1972 until February 1974.

CHEMICAL DATA
Chemical samples were taken monthly from March 1972 until February 1974. All chemical analyses were done on filtered samples by the National Institute for Water Research (NIWR) based on Standard Methods for the Examination of Water and Waste Water (1971). The following variables are reported in the document. The relevant details in terms of conversions and assumptions are reported.

- conductivity (COND): No units were given in the document. By calculation of TDS and conversion into conductivity, it was calculated to be in μS cm^{-1}. These were then converted to mS m^{-1}.
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ and converted to meq ℓ^{-1}
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- chemical oxygen demand (COD), mg ℓ^{-1}
- total inorganic carbon (TIC), mg ℓ^{-1}
- total organic carbon (TOC), mg ℓ^{-1}
- dissolved inorganic nitrogen (DIN), mg ℓ^{-1}
- dissolved organic nitrogen (DON), mg ℓ^{-1}
- nitrate (NO3-N), mg ℓ^{-1}
- nitrite (NO2-N), mg ℓ^{-1}

- ammonia nitrogen (NH4-N), mg ℓ^{-1}
- total phosphorous (TOT-P), mg ℓ^{-1}
- PO_4-P, assumed equivalent to soluble reactive phosphorus (SRP), mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological and chemical data were matched on a monthly basis.

STUDY REFERENCE: 6

RIVERS	RIVERS OF NEWCASTLE AND LADYSMITH AREA, NATAL
REFERENCE	FOWLES B.K., BUTLER A.C., BROWN H.M., KEMP P.H., COETZEE O.J. & METZ H. 1979. WATER QUALITY AND ABATEMENT OF POLLUTION IN NATAL RIVERS. PART VII. SPECIAL STUDIES IN THE RAPIDLY DEVELOPING AREAS OF NEWCASTLE AND LADYSMITH. NATAL TOWN AND REGIONAL PLANNING COMMISSION.

BIOLOGICAL DATA

Biotopes sampled:		Sampling devices:
A) stony bottom:	stone-in-current	hand net
B) vegetation:	marginal vegetation	hand net (1-4m sweep)

Mesh size = 300 μm. One sample per biotope was taken each month.

CHEMICAL DATA
Water samples for chemical analysis were collected monthly between February 1975 and January 1976. The standard analytical methods of the National Institute for Water Research were used. The following variables were measured:
- temperature (TEMP), mean (in °C)
- pH (PH)
- conductivity (COND), mS m^{-1}
- dissolved oxygen (DO), mg ℓ^{-1}
- dissolved oxygen % saturation (DOPER), %
- biological oxygen demand (BOD): 5-day measured in mg ℓ^{-1}
- Kjeldahl nitrogen (KJN), in mg ℓ^{-1}
- nitrate (NO3-N), mg ℓ^{-1}
- phosphate, mg ℓ^{-1}, assumed equivalent to soluble reactive phosphorus (SRP)
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ converted to meq ℓ^{-1}
- total hardness (CACO3), mg ℓ^{-1} $CaCO_3$
- calcium (CA), magnesium (MG), sulphate (SO4), chloride (CL), all in mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Monthly biological data for each site have been linked with the chemical data for the same month.

STUDY REFERENCE: 7

RIVERS	KUBUSI RIVER
REFERENCE	O'KEEFFE J.H. 1990. KUBUSI RIVER ECOLOGICAL ASSESSMENT. A PRELIMINARY ASSESSMENT OF THE KUBUSI RIVER AT WRIGGLESWADE, WITH RECOMMENDATIONS FOR THE OPERATION OF WRIGGLESWADE DAM SO AS TO MINIMISE ECOLOGICAL DISRUPTION DOWNSTREAM. UNPUBLISHED REPORT FOR THE DEPARTMENT OF WATER AFFAIRS.

BIOLOGICAL DATA

Biotope sampled:		Sampling device:
A) stony bottom:	stone-in-current	Box sampler (0.055 m^2)

Mesh size = 80 μm. Benthic samples were collected in May 1988 at 5 sites in a 45km stretch of the Kubusi River.

CHEMICAL DATA
A single set of chemical samples was taken in May 1988. The following variables are reported.
- conductivity (COND), mS m^{-1}
- pH (PH)
- total alkalinity (TAL), mg ℓ^{-1} and converted to meq ℓ^{-1}
- nitrite + nitrate (NO2+NO3), mg ℓ^{-1}
- ammonium (NH4-N), mg ℓ^{-1}
- PO_4-P, assumed equivalent to soluble reactive phosphorus (SRP), in mg ℓ^{-1}
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- turbidity (NTU), in NTUs
- total suspended solids (TSS), in mg ℓ^{-1}
- chlorophyll *a* (CHLA), in μg ℓ^{-1} and converted to mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological and chemical data were matched directly.

STUDY REFERENCE: 8

RIVER	YELLOWWOODS RIVER
REFERENCE	O'KEEFFE J.H. 1987. ECOLOGICAL IMPACTS OF AN INTERBASIN TRANSFER OF WATER TO THE YELLOWWOODS RIVER (EASTERN CAPE PROVINCE): A PRELIMINARY ASSESSMENT.

BIOLOGICAL DATA
The biotope sampled and the sampling device used were dependent on the amount of water which was extremely low at most sites.

Biotope sampled:		Sampling device:
A) stony bottom:	riffle (at sites 3, 6, 7)	Box sampler
	riffle (at site 1A, 2, 4)	sieve
	stone-out-of-current (at site 5)	sieve

Mesh size of the Box sampler was 80 μm, and of the sieve 1 mm. Benthic samples were collected in July 1987 at 7 sites.

CHEMICAL DATA
A single set of chemical samples (filtered water samples) was taken on 18 July 1987. The following variables are reported.
- temperature (TEMP), °C
- conductivity (COND), mS m^{-1}
- pH (PH)
- total dissolved solids (TDS), mg ℓ^{-1}
- total alkalinity (TAL), mg ℓ^{-1} and converted to meq ℓ^{-1}
- nitrite (NO2-N), mg ℓ^{-1}
- nitrate (NO3-N), mg ℓ^{-1}
- ammonia (NH4-N), mg ℓ^{-1}
- PO_4, assumed equivalent to soluble reactive phosphorus (SRP), mg ℓ^{-1}
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- total suspended solids (TSS), in mg ℓ^{-1}
- % organics (%ORG IN TSS), %
- chlorophyll *a* (CHLA), in μg ℓ^{-1} and converted to mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological and chemical data were matched directly.

STUDY REFERENCE: 9

RIVERS	ORANGE FREE STATE RIVERS
REFERENCE	ANONYMOUS. 1966. HIDROCHEMIE VAN DIE BELANGRIKSTE VRYSTAATSE RIVIERE. NATIONALE INSTITUUT VIR WATERNAVORSING WETENSKAPLIKE EN NYWERHEIDNAVORSINGSRAAD. WNNR NAVORSINGSVERSLAG 252. PP1-179. PRETORIA.

BIOLOGICAL DATA

Biotopes sampled:		Sampling device:
A) stony bottom:	stone-in-current	Surber sampler or hand net
B) vegetation:	marginal vegetation	hand net

Mesh size 950 μm. Ten sites were sampled in April 1964 and one in October 1963. Species abundance was converted into percentages at each site where this was not done in the reference.

CHEMICAL DATA
Chemical samples were taken at nine sites in April 1964. The following variables are reported in the document. Any relevant conversion details and assumptions are detailed below.

- pH (PH)
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ and converted to meq ℓ^{-1}
- total hardness (CACO3), mg ℓ^{-1}
- total dissolved solids (TDS), mg ℓ^{-1}
- total suspended solids (TSS), mg ℓ^{-1}
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- biological oxygen demand (BOD, 5-day), mg ℓ^{-1}
- Kjeldahl-nitrogen (KJN), mg ℓ^{-1}
- nitrate (NO3-N), mg ℓ^{-1}
- PO_4-P, assumed equivalent to soluble reactive phosphorus (SRP), mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Chemical data from the nine sites were collected on the same date as the biological samples at the same sites. Direct matching was thus possible.

STUDY REFERENCE: 10

RIVER	MOOI RIVER
REFERENCE	O'KEEFFE J.H. 1989. REPORT OF AN INVESTIGATION OF WATER QUALITY IN THE UPPER MOOI RIVER. UNPUBLISHED REPORT OF THE INSTITUTE FOR FRESHWATER STUDIES, RHODES UNIVERSITY, GRAHAMSTOWN.

BIOLOGICAL DATA

Biotope sampled:		Sampling device:
A) stony bottom:	stone-in-current	Box sampler

Mesh size = 80 μm. Benthic samples were collected on 31 October 1989 from 6 sites.

CHEMICAL DATA
A single set of chemical samples was taken on 31 October 1989. The following variables are

reported.

- water temperature (TEMP), °C
- conductivity (COND), mS m^{-1}
- pH (PH)
- total alkalinity (TAL), mg ℓ^{-1} and converted to meq ℓ^{-1}
- nitrite (NO2-N), in μmol ℓ^{-1} and converted to mg ℓ^{-1}
- nitrate (NO3-N), in μmol ℓ^{-1} and converted to mg ℓ^{-1}
- ammonium (NH4-N), in μmol ℓ^{-1} and converted to mg ℓ^{-1}
- PO_4, assumed equivalent to soluble reactive phosphorus (SRP), in μmol ℓ^{-1} and converted to mg ℓ^{-1}
- Percentage dissolved oxygen (DOPER), %
- chlorophyll *a* (CHLA), in μg ℓ^{-1} and converted to mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological and chemical data were matched directly.

STUDY REFERENCE: 11

RIVER	SWARTBOSKLOOF STREAM, SOUTH-WESTERN CAPE
REFERENCE	BRITTON D.L. 1990. A STUDY OF A CAPE MOUNTAIN STREAM ECOSYSTEM AND ITS RESPONSE TO FIRE. Ph.D THESIS, UNIVERSITY OF CAPE TOWN.

BIOLOGICAL DATA

Biotope sampled:		Sampling device:
A) stony bottom:	riffle	Box sampler

Mesh size = 80 μm. Three samples were collected each month from Jan1986 until March 1988.

CHEMICAL DATA
The following variables were measured. The relevant details in terms of conversions and assumptions are reported.

- pH (PH)
- conductivity (COND), mS m^{-1}
- total alkalinity (TAL), given as mg ℓ^{-1} CO_3, converted to meq ℓ^{-1}
- total dissolved solid (TDS), mg ℓ^{-1}
- total suspended solid (TSS), mg ℓ^{-1}
- total organics (TORGS), mg ℓ^{-1}
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- nitrate (NO3-N), μmol ℓ^{-1}, converted to mg ℓ^{-1}
- nitrite (NO2-N), μmol ℓ^{-1}, converted to mg ℓ^{-1}
- ammonium (NH4-N), μmol ℓ^{-1}, converted to mg ℓ^{-1}
- PO_4-P, assumed equivalent to soluble reactive phosphorus (SRP),in μmol ℓ^{-1}, converted to mg ℓ^{-1}
- Phenols (PHEN), mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological and chemical data were matched on a monthly basis.

STUDY REFERENCE: 12

RIVER	BUFFALO RIVER, NATAL
REFERENCE	FOWLES, B.K. 1984A. SURVEY OF THE BUFFALO RIVER DURING ATYPICAL FLOW CONDITIONS. PART 111C. UNPUBLISHED NATIONAL

ISTITUTE FOR WATER RESEARCH REPORT.

This study was undertaken to determine the biological and chemical characteristics of the Buffalo River and its tributaries *during extremely atypical drought conditions* (1 in 200-year drought).

BIOLOGICAL DATA

Biotopes sampled:		Sampling devices:
A) stony bottom:	stone-in-current	Surber sampler
B) vegetation:	marginal vegetation	hand net
C) sediment:	mixed	Birge-Ekman grab sampler

Mesh size = 300 μm. Sites were sampled once in September 1983. The number of individuals of each taxon are expressed as a percentage of the total number of animals found in a sample.

CHEMICAL DATA

One-off water samples were collected at each site in September 1983. They were analysed using the standard analytical methods of the National Institute for Water Research. The following variables were measured:

- temperature (TEMP), °C)
- pH (PH)
- conductivity (COND), given as mS m^{-1} at 20°C and converted to mS m^{-1} at 25°C
- total suspended solids (TSS), mg ℓ^{-1}
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ converted to meq ℓ^{-1}
- dissolved oxygen (DO), mg ℓ^{-1}
- dissolved oxygen % saturation (DOPER), %
- soluble reactive phosphorus (SRP), in μg ℓ^{-1} and converted to mg ℓ^{-1}
- total phosphorus (filtered) (TOT-P), in μg ℓ^{-1} and converted to mg ℓ^{-1}
- Kjeldahl nitrogen (filtered) (KJN), in μg ℓ^{-1} and converted to mg ℓ^{-1}
- nitrate (NO3-N), in μg ℓ^{-1} and converted to mg ℓ^{-1}
- nitrite (NO2-N), in μg ℓ^{-1} and converted to mg ℓ^{-1}
- ammonia (NH4-N), in μg ℓ^{-1} and converted to mg ℓ^{-1}
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- sodium, (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- soluble silica (SI), mg ℓ^{-1}
- iron (FE), μg ℓ^{-1} and converted to mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA

The biological data and chemical data have been linked directly.

STUDY REFERENCE: 13

RIVERS	RIVERS OF THE TUGELA BASIN, NATAL
REFERENCE	FOWLES, B.K. 1984B. CHEMICAL AND BIOLOGICAL RESURVEY OF THE RIVERS OF THE TUGELA BASIN. PART IIIC. UNPUBLISHED NATIONAL INSTITUTE FOR WATER RESEARCH REPORT.

BIOLOGICAL DATA

Biotopes sampled:		Sampling devices:
A) stony bottom:	stone-in-current	Surber sampler

Mesh size = 300 μm. 16 sites were sampled in August 1984. The number of individuals of each taxon are expressed as a percentage of the total number of animals found in a sample.

CHEMICAL DATA

One-off water samples were collected at 10 sites in August 1984. They were analysed using the standard analytical methods of the National Institute for Water Research. The following variables were measured:

- temperature (TEMP), °C
- pH (PH)
- conductivity (COND), given as mS m^{-1} at 20°C and converted to mS m^{-1} at 25°C
- total dissolved solids (TDS), mg ℓ^{-1}
- total suspended solids (TSS), mg ℓ^{-1}
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ converted to meq ℓ^{-1}
- dissolved oxygen (DO), mg ℓ^{-1}
- dissolved oxygen % saturation (DOPER), %
- free carbon dioxide (FREE CO2), mg ℓ^{-1}
- soluble reactive phosphorus (SRP), in μg ℓ^{-1} and converted to mg ℓ^{-1}
- total phosphorus (filtered) (TOT-P), in μg ℓ^{-1} and converted to mg ℓ^{-1}
- Kjeldahl nitrogen (filtered) (KJN), in μg ℓ^{-1} and converted to mg ℓ^{-1}
- dissolved organic nitrogen (DON), in mg ℓ^{-1}
- nitrate (NO3-N), in μg ℓ^{-1} and converted to mg ℓ^{-1}
- nitrite (NO2-N), in μg ℓ^{-1} and converted to mg ℓ^{-1}
- ammonia (NH4-N), in μg ℓ^{-1} and converted to mg ℓ^{-1}
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- sodium, (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- soluble silica (SI), mg ℓ^{-1}
- iron (FE), μg ℓ^{-1} and converted to mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
The biological data and chemical data from the common sites have been linked directly.

STUDY REFERENCE: 14 AND 15

RIVER	SOUTH WESTERN CAPE RIVERS
REFERENCE	14: HARRISON A.D. & AGNEW J.D. 1962. THE DISTRIBUTION OF INVERTEBRATES ENDEMIC TO ACID STREAMS IN THE WESTERN AND SOUTHERN CAPE PROVINCE. ANN. CAPE PROV. MUS. II. SOUTH AFRICA, 273-291.
	15: HARRISON A.D. & AGNEW J.D. 1960. EXPLORATORY SURVEY OF EASTERN PART OF REGION A (SOUTH WESTERN CAPE) AND REGION B. NATIONAL INSTITUTE FOR WATER RESEARCH REPORT NO. 5 (PROJECT 6.8.H. REF W.6/6/8H.

BIOLOGICAL DATA

Biotopes sampled:		Sampling devices:
A) stony bottom:	stone-in-current	Surber sampler and hand net
	pools	Surber sampler and hand net
	stony backwaters	Surber sampler and hand net
B) vegetation:	marginal vegetation	hand net

Mesh size » 950 μm. Faunal samples were collected during March 1960.

CHEMICAL DATA
The primary aim of the study was to determine the relationship between the biota and pH. For this reason pH was recorded at all sites, whilst other chemical variables were only recorded at some of the sites. The following variables are reported:

- pH: mean (PH), max (PHMAX) and min (PHMIN) values measured using a Lovibond Comparator;
- total dissolved solids (TDS), in mg ℓ^{-1} (mean, max and min values given)

- total alkalinity (TAL): in mg ℓ^{-1} converted to meq ℓ^{-1}
- total hardness (CACO3): in mg ℓ^{-1}
- calcium (CA) in mg ℓ^{-1}; (mean, max and min values given)
- magnesium (MG) in mg ℓ^{-1} (mean, max and min values given)
- sodium (NA) in mg ℓ^{-1} (mean, max and min values given)
- potassium (K) in mg ℓ^{-1} (mean, max and min values given)
- sulphate (SO4) in mg ℓ^{-1} (mean, max and min values given)
- chloride (CL) in mg ℓ^{-1} (mean, max and min values given)

MATCHING BIOLOGICAL AND CHEMICAL DATA
The biological and chemical data were collected at the same time period and were therefore matched directly.

STUDY REFERENCE: 16

RIVER	SUNDAYS RIVER
REFERENCE	FORBES A.T. 1968. CONTRIBUTIONS TO THE ECOLOGY OF THE SUNDAYS RIVER. UNPUBLISHED M.SC THESIS, DEPARTMENT OF ZOOLOGY, RHODES UNIVERSITY.

BIOLOGICAL DATA

Biotopes sampled:		Sampling devices:
A) stony bottom:	stone-in-current	Surber sampler or hand net
	stone-out-of-current	Surber sampler or hand net
	slow flowing water	Surber sampler or hand net
	rapidly flowing water	Surber sampler or hand net
B) vegetation:	marginal vegetation	hand net
	vegetation in water	hand net

Mesh size = 900 μm. Faunal samples were taken in February and July 1967.

CHEMICAL DATA
Chemical samples were collected at the same time as faunal samples. The following variables were reported:

- pH
- total dissolved solids (TDS), mg ℓ^{-1}
- carbonate (CO3), mg ℓ^{-1}
- bicarbonate (HCO3), mg ℓ^{-1}
- total alkalinity (TAL), calculated by adding carbonate and bicarbonate concentrations (mg ℓ^{-1}), and converting to meq ℓ^{-1}
- dissolved oxygen (DO), mg ℓ^{-1}
- nitrate (NO3-N), mg ℓ^{-1}
- phosphate taken to be equivalent to soluble reactive phosphorus (SRP), mg ℓ^{-1}
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological and chemical data were matched directly.

STUDY REFERENCE: 17

RIVER	GREAT FISH RIVER
REFERENCE	ALLANSON B.R. 1968. AN INTRODUCTORY NOTE ON THE CHEMISTRY

AND BIOLOGY OF THE GREAT FISH RIVER. DIRECTOR'S REPORT, INSTITUTE FOR FRESHWATER STUDIES, RHODES UNIVERSITY.

BIOLOGICAL DATA

Biotope sampled:		Sampling device:
A) stony bottom:	stone-in-current	hand net (two to five samples)

Faunal samples were taken in July 1964 and February 1965. Animal abundances (%) were calculated from the raw data given.

CHEMICAL DATA
Chemical samples were collected at the same time as faunal samples. The following variables were reported:

- temperature (TEMP), °C
- pH (PH)
- total dissolved solids (TDS), mg ℓ^{-1}
- calcium (CA), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological and chemical data were matched directly.

NOTE: Data from this study are subsequently discussed and compared in the study: O'Keeffe J.H. & De Moor F.C. 1988. Changes in the physico-chemistry and benthic invertebrates of the Great Fish River, South Africa, following an interbasin transfer of water. *Regulated Rivers: research and management* 2: 39-55.

STUDY REFERENCE: 18

RIVER	GREAT FISH RIVER
REFERENCE	PALMER R.W. & O'KEEFFE J.H. 1990. DOWNSTREAM EFFECTS OF A SMALL IMPOUNDMENT ON A TURBID RIVER. ARCH. HYDROBIOL. 119 (4): 457-473.

BIOLOGICAL DATA

Biotope sampled:		Sampling device:
A) stony bottom:	stone-in-current	Box sampler

Mesh size = 80 μm. Three samples were collected during each sampling period.

CHEMICAL DATA
The following variables were measured. The relevant details in terms of conversions and assumptions are detailed.

- temperature (TEMP), °C
- pH (PH)
- conductivity (COND), mS m^{-1}
- total alkalinity (TAL), given as mg ℓ^{-1}, converted to meq ℓ^{-1}
- total dissolved solids (TDS), mg ℓ^{-1}
- total suspended solids (TSS), mg ℓ^{-1}
- % organics in TSS (% ORG IN TSS), mg ℓ^{-1}
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- silica (SI), mg ℓ^{-1}
- nitrate (NO3-N), μmol ℓ^{-1}, converted to mg ℓ^{-1}
- nitrite (NO2-N), μmol ℓ^{-1}, converted to mg ℓ^{-1}
- ammonium (NH4-N), μmol ℓ^{-1}, converted to mg ℓ^{-1}
- soluble reactive phosphate (SRP), μmol ℓ^{-1}, converted to mg ℓ^{-1}
- turbidity (NTU), in NTUs
- chlorophyll *a* (CHLA), μg ℓ^{-1} converted to mg ℓ^{-1}
- particulate organic matter (POM), mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological and chemical data were matched for each sampling period. NOTE: Data used are from the original raw datasheets, provided by the authors.

STUDY REFERENCE: 19

RIVER	BREEDE RIVER
REFERENCE	COETZER A.H. 1986. BENTHIC INVERTEBRATE COMMUNITIES AND THE BIOLOGICAL ASSESSMENT OF THE WATER QUALITY OF THE BREEDE RIVER DURING 1975 AND 1976. BONTEBOK 5: 42-51.

BIOLOGICAL DATA

Biotopes sampled:		Sampling devices:
A) stony bottom:	stone-in-current	hand net or Surber sampler

Mesh size = 290 μm. Qualitative macro-invertebrate sampling was carried out in the first week of March in 1975 and 1976.

CHEMICAL DATA
No chemical data were collected.

STUDY REFERENCE: 20

RIVERS	MOUNTAIN STREAMS OF THE BARBERTON AREA
REFERENCE	HUGHES D.A. 1966. MOUNTAIN STREAMS OF THE BARBETON AREA, EASTERN TRANSVAAL. PART 1, A SURVEY OF THE FAUNA. HYDROBIOLOGIA 27: 401-438. HUGHES D.A. 1966. MOUNTAIN STREAMS OF THE BARBERTON AREA, EASTERN TRANSVAAL. PART 2, THE EFFECT OF VEGETATIONAL SHADING AND DIRECT ILLUMINATION ON THE DISTRIBUTION OF STREAM FAUNA. HYDROBIOLOGIA 27: 439-459.

BIOLOGICAL DATA

Biotopes sampled:		Sampling devices:
A) stony bottom:	cascades	cascade net
	spray flanking regions	round tin sampler
	stickles	Surber sampler
	backwaters	hand net
	pools	hand net

No mesh size given. Sampling was conducted in May and July 1961.

CHEMICAL DATA
No chemical data were collected.

STUDY REFERENCE: 21

RIVERS	SABIE AND GROOT-LETABA RIVERS
REFERENCE	O'KEEFFE J.H. 1985. THE CONSERVATION STATUS OF THE SABIE AND GROOT LETABA RIVERS WITHIN THE KRUGER NATIONAL PARK. SPECIAL REPORT NO. 85/2, INSTITUTE FOR FRESHWATER STUDIES, RHODES UNIVERSITY.

BIOLOGICAL DATA

Biotopes sampled:		Sampling devices:
A) stony bottom: stone-in-current		hand net
	rock in current	scraping method
b) vegetation:	marginal vegetation	hand net

300 μm mesh size used. Sampling was conducted in January 1985.

CHEMICAL DATA
No chemical data were collected.

STUDY REFERENCE: 22

RIVERS	THREE RIVERS REGION
REFERENCE	BRAND P.A.J., KEMP P.H., PRETORIUS S.J. & SCHOONBEE H.J. 1967. WATER QUALITY AND ABATEMENT OF POLLUTION IN NATAL RIVERS. PART II. SURVEY OF THE THREE RIVERS REGION. NATIONAL INSTITUTE FOR WATER RESEARCH, CSIR AND THE TOWN AND REGIONAL PLANNING COMMISSION REPORT.

BIOLOGICAL DATA

Biotopes sampled:		Sampling devices:
A) vegetation:	marginal vegetation	hand net (2-3m sweep)
B) sediment:	mixed	corer (3/sample)

Mesh size = 300 μm. The survey commenced in 1962. All sites were sampled once, with the exception of a more intense survey program on the Umgeni River conducted from 1958 to 1962.

CHEMICAL DATA
Values given are the means expressed as a rainy and a dry season value. The latter is reported in the database as this is the period during which benthic collections were undertaken. In the Umgeni River, biological and chemical sampling were done at the same time, although the exact dates were not specified in the literature. The following variables were measured:

- temperature (TEMP), mean (in °C)
- pH (PH)
- conductivity (COND), micromhos, converted to mS m^{-1}
- total dissolved solids (TDS), mg ℓ^{-1}
- dissolved oxygen (DO), mg ℓ^{-1}
- dissolved oxygen % saturation (DOPER), %
- biological oxygen demand (BOD): 5-day measured in mg ℓ^{-1}
- Kjeldahl nitrogen (KJN), in mg ℓ^{-1}
- nitrate (NO3-N), mg ℓ^{-1}
- nitrite (NO2-N), mg ℓ^{-1}
- ammonia (NH4-N), mg ℓ^{-1}
- phosphate, mg ℓ^{-1} assumed equivalent to SRP
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ converted to meq ℓ^{-1}
- total hardness (CACO3), mg ℓ^{-1} $CaCO_3$
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- fluoride (F), mg ℓ^{-1}
- silica (SI), mg ℓ^{-1}
- iron (FE), mg ℓ^{-1}
- free carbonic acid (FREE CO2), as mg ℓ^{-1} CO_2
- turbidity (TURB), mg ℓ^{-1} silica scale
- colour (COL), APHA units

MATCHING BIOLOGICAL AND CHEMICAL DATA
The biological data for each site (sampled in the dry season) has been linked with the chemical data for the dry season.

STUDY REFERENCE: 23

RIVER	VAAL RIVER
REFERENCE	CHUTTER F.M. 1963. HYDROBIOLOGICAL STUDIES ON THE VAAL RIVER IN THE VEREENIGING AREA. PART 1: INTRODUCTION, WATER CHEMISTRY AND BIOLOGICAL STUDIES ON THE FAUNA OF HABITATS OTHER THAN MUDDY BOTTOM SEDIMENTS. HYDROBIOLOGIA 21 (1/2): 1-65.

BIOLOGICAL DATA

Biotopes sampled:		Sampling devices:
A) stony bottom:	stony run	Surber sampler
	backwater	hand net
B) vegetation:	marginal vegetation	hand net
	aquatic weed	hand net

Mesh size » 950 μm. Sites were sampled monthly and data are given as the average percentage composition on a seasonal basis. The number of individuals of each taxon are expressed as a percentage of the total number of animals found in a sample. Rare species were recorded as being present or absent and given the value "0.01" in the database.

CHEMICAL DATA
Water samples for chemical analysis were collected monthly. Mean, minimum and maximum values are given on a seasonal basis. The following variables were measured:
- pH (PH)
- conductivity (COND), microhos at 20°C, converted to mS m^{-1} at 25°C
- total dissolved solids (TDS), mg ℓ^{-1}
- total suspended solids (TSS), mg ℓ^{-1}
- nitrate (NO3-N), mg ℓ^{-1}
- nitrite (NO2-N), mg ℓ^{-1}
- ammonia (NH4-N), mg ℓ^{-1}
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ converted to meq ℓ^{-1}
- total hardness (CACO3), mg ℓ^{-1} $CaCO_3$
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}

Some variables were not detectable and these have been entered as 0.0001 mg ℓ^{-1}; others were found in trace amounts, entered as 0.0009 mg ℓ^{-1}.

MATCHING BIOLOGICAL AND CHEMICAL DATA
The biological data for each site have been matched with the chemical data within the same or similar time period. Caution should be taken when using combined biological and chemical data.

STUDY REFERENCE: 24

RIVERS	GREAT BERG RIVER AND TRIBUTARIES
REFERENCE	SCOTT K.M.F. 1958. HYDROBIOLOGICAL STUDIES OF THE GREAT BERG RIVER, WESTERN CAPE PROVINCE. PART 3. THE CHIRONOMIDAE. TRANSACTIONS OF THE ROYAL SOCIETY OF SOUTH AFRICA. VOL. 35. PART 3. PP.277-298.

BIOLOGICAL DATA

Biotopes sampled:	Sampling devices:
stone-in-current	hand net
backwater	hand net
marginal vegetation	hand net
pool	hand net
sandy bottom	hand net
mix of all biotopes	

Adult midges and larvae (bred out) were collected simultaneously to the main Berg River study (Harrison & Elsworth 1958, study reference No.1) from 1951 to 1953. Intensive collection sites included BRG3, BRG12, and BRG18; subsidiary sites: ASSEG1 (Assegaaibosch tributary), ASSEG2 (Assegaaibosch Kloof Waterfall), BRG1, BRG5, BRG10; and small collection sites: BRG4 (Franschhoek tributary), BRG6 (Wemmers tributary), BRG9, BRG13 and BRG21. Presence or absence only is recorded.

CHEMICAL DATA

Chemical data from some of the main Berg River sites may be matched with biological data from this study. However, the nature of the collections and the sampling periods make direct matching problematic. For this reason, no matching of biological and chemical data has been undertaken.

STUDY REFERENCE: 25

RIVERS	DWARS RIVER, KROM RIVER
REFERENCE	HARRISON A.D. 1958B. HYDROBIOLOGICAL STUDIES OF THE GREAT BERG RIVER, WESTERN CAPE PROVINCE. PART 4. THE EFFECTS OF ORGANIC POLLUTION ON THE FAUNA OF PARTS OF THE GREAT BERG RIVER SYSTEM AND OF THE KROM STREAM, STELLENBOSCH. VOL. 35. PART 3. PP.299-329.

BIOLOGICAL DATA

River:	Biotopes sampled:	Sampling devices:
Dwars River:	stony runs and stickles	hand net
Plankenbrug Stream:	stony runs and stickles	hand net
Krom River:	stony runs and stickles	hand net
	marginal vegetation	hand net

Mesh size » 950 μm. Biological samples were collected in February, July, September, November 1951 and January, March and April 1952 on the Dwars River (HAR5). The Plankenbrug Stream and Krom River were sampled monthly from August 1952 to January 1953 (sites HAR1 and HAR2) and April 1953 (HAR4).

CHEMICAL DATA

The following variables are reported:

- pH (PH), measured using a Beckman pH probe
- total dissolved solids (TDS), mg ℓ^{-1}
- total alkalinity (TAL): in mg ℓ^{-1} converted to meq ℓ^{-1}
- dissolved oxygen (DO), mg ℓ^{-1}
- dissolved oxygen % saturation (DOPER), %
- biological oxygen demand (BOD), 5-day measured in mg ℓ^{-1}
- albuminoid ammonia, equivalent to Kjeldahl nitrogen (KJN) (Elsworth, pers. comm.), (KJN) in mg ℓ^{-1}
- ammonia nitrogen, equivalent to total ammonia (NH4-N), mg ℓ^{-1}
- nitrate (NO3-N), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- turbidity (TURB): mg ℓ^{-1} SiO_2

MATCHING BIOLOGICAL AND CHEMICAL DATA

"Spot" chemical samples were taken at the same time as biological samples. They are therefore matched directly.

STUDY REFERENCE: 26

RIVERS	OLIFANTS RIVER, SOUTH-WESTERN CAPE
REFERENCE	KING J.M. & THARME R.E. 1994. ASSESSMENT OF THE INSTREAM FLOW INCREMENTAL METHODOLOGY AND INITIAL DEVELOPMENT OF ALTERNATIVE INSTREAM FLOW METHODOLOGIES FOR SOUTH AFRICA. WRC REPORT NO. 295/1/94. REPORT TO THE WATER RESEARCH COMMISSION BY THE FRESHWATER RESEARCH UNIT, UNIVERSITY OF CAPE TOWN.

BIOLOGICAL DATA

Biotopes sampled:		Sampling devices:
A) stony bottom:	cobble/bedrock riffle	Box sampler
	bedrock rapid	Box sampler
	bedrock run	Box sampler
	cobble riffle	Box sampler
	cobble run	Box sampler
	cobble backwater	Box sampler
	gravel/cobble backwater	Box sampler
	bedrock pool (38)	Box sampler
	bedrock/cobble pool	Box sampler
	bedrock/cobble rapid	Box sampler
	bedrock/boulder run	Box sampler
	cobble/bedrock run	Box sampler
B) sandy bottom:	sand/gravel run	corer
	sand run	corer
	sand backwater	corer
	sand pool	corer
	silt/sand pool	corer

Mesh size = 80 μm. Eleven sites were sampled once in summer 1991. The number of samples within each biotope was dependent on the relative proportion of each biotope at each sampling site. The mean number of animals per biotope was calculated for each site.

CHEMICAL DATA

Chemical data were collected at the same time as biological data. The following variables were measured. The relevant details in terms of conversions and assumptions are detailed.

- temperature (TEMP), °C (mean, minimum, maximum)
- pH (PH)
- conductivity (COND), mS m^{-1} at 25°C
- total alkalinity (TAL), meq ℓ^{-1}
- phenolthalein alkalinity (PHALK), meq ℓ^{-1}
- total dissolved solid (TDS), mg ℓ^{-1}
- total suspended solid (TSS), mg ℓ^{-1}
- percentage organics in TSS (%ORG IN TSS), %
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- nitrate (NO3-N), μmol ℓ^{-1}, converted to mg ℓ^{-1}
- nitrite (NO2-N), μmol ℓ^{-1}, converted to mg ℓ^{-1}
- ammonium (NH4-N), μmol ℓ^{-1}, converted to mg ℓ^{-1}
- PO_4-P, assumed equivalent to soluble reactive phosphate (SRP), in μmol ℓ^{-1}, converted to mg ℓ^{-1}
- iron (FE), mg ℓ^{-1}
- copper (CU), mg ℓ^{-1}
- silica (SI), mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA

Biological and chemical data were matched directly.

STUDY REFERENCE: 27

RIVERS	MOLENAARS RIVER, BERG RIVER, EERSTE RIVER, FRANSCHHOEK RIVER, KRAALSTROOM RIVER (ALL SOUTH-WESTERN CAPE)
REFERENCE	BROWN C. 1993. INITIAL SURVEYS IN THE INVESTIGATION TO DETERMINE THE EFFECTS OF TROUT FARM EFFLUENT ON RIVERINE BIOTAS IN THE SOUTH-WESTERN CAPE. FINAL INTERIM REPORT TO THE DEPARTMENT OF WATER AFFAIRS AND FORESTRY.

Since the primary aim of this study was the determination of the potential effect of trout farms on riverine biotas, sites were selected to best represent an unimpacted/control site (above the inlet), an effluent site, and a recovery site (100 m below the effluent outlet) at each farm.

BIOLOGICAL DATA

Biotope sampled:		Sampling device:
stony bottom:	riffle	Box sampler

Mesh size = 80 μm. Three samples were collected from each site in August 1991 and February 1992.

CHEMICAL DATA
The following water quality variables were measured at the same time as the collecting of biological samples. The relevant details in terms of conversions and assumptions are detailed.

- temperature (TEMP), °C
- pH (PH)
- conductivity (COND), μS cm^{-1} and converted to mS m^{-1}
- total dissolved solid (TDS), mg ℓ^{-1}
- total suspended solid (TSS), mg ℓ^{-1}
- dissolved oxygen (DO), mg ℓ^{-1}
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- nitrate (NO3-N), μmol ℓ^{-1}, converted to mg ℓ^{-1}
- nitrite (NO2-N), μmol ℓ^{-1}, converted to mg ℓ^{-1}
- ammonium (NH4-N), μmol ℓ^{-1}, converted to mg ℓ^{-1}
- PO_4-P, assumed equivalent to soluble reactive phosphorus (SRP), μmol ℓ^{-1}, converted to mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological and chemical data were matched directly for the two sampling periods.

STUDY REFERENCE: 28

RIVER	ORANGE RIVER
REFERENCE	PALMER R.W. 1992. BLACKFLY CONTROL PROJECT. PROGRESS REPORT FOR WATER RESEARCH COMMISSION.

BIOLOGICAL DATA

Biotopes sampled:		Sampling device:
A) stony bottom:	stone-in-current	Box sampler
	stone-out-of-current	Box sampler
B) vegetation	marginal vegetation	hand net

Most sites were sampled once in February 1992. Gifkloof (GIF) was sampled monthly from July 1991 to March 1992. All abundance data are reported in terms of presence or absence only.

CHEMICAL DATA

Only temperature (TEMP) in ºC, and total suspended solids (TSS) in mg ℓ^{-1}, were measured.

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological and chemical data were matched directly.

STUDY REFERENCE: 29

RIVERS	TUGELA RIVER AND ITS TRIBUTARIES.
REFERENCE	BRAND P.A.J., KEMP P.H., OLIFF W.D. & PRETORIUS S.J. 1967. WATER QUALITY AND ABATEMENT OF POLLUTION IN NATAL RIVERS. PART III. THE TUGELA RIVER AND ITS TRIBUTARIES. NATIONAL INSTITUTE FOR WATER RESEARCH, CSIR AND THE TOWN AND REGIONAL PLANNING COMMISSION REPORT.

BIOLOGICAL DATA

Biotope sampled:		Sampling device:
A) vegetation:	marginal vegetation	hand net

Mesh size = 300 μm. The survey was divided into different time periods and was conducted by different workers. All sites were sampled once.

CHEMICAL DATA
Values given are the average values for the following time periods : Bushmans River: 1956-1957; Buffalo River and tributaries: 1959-1960; Mooi River: 1961; Sundays River: 1960-1963. The variables listed below were measured:

- pH (PH)
- conductivity (COND), micromhos, converted to mS m^{-1}
- total dissolved solids (TDS), mg ℓ^{-1}
- biological oxygen demand (BOD): 5-day measured in mg ℓ^{-1}
- nitrate (NO3-N), mg ℓ^{-1}
- phosphate, mg ℓ^{-1} assumed equivalent to SRP
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ converted to meq ℓ^{-1}
- total hardness (CACO3), mg ℓ^{-1} $CaCO_3$
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- silica (SI), mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
The biological data for each site have been linked with the average yearly chemical data for the same time period, and should therefore be treated with caution.

STUDY REFERENCE: 30

RIVERS	NORTHERN NATAL AND ZULULAND.
REFERENCE	ARCHIBALD C.G.M., COETZEE O.J., KEMP P.H., PRETORIUS S.J. & SIBBALD R.R. 1969. WATER QUALITY AND ABATEMENT OF POLLUTION IN NATAL RIVERS. PART IV. THE RIVERS OF NORTHERN NATAL AND ZULULAND. NATIONAL INSTITUTE FOR WATER RESEARCH, CSIR AND THE TOWN AND REGIONAL PLANNING COMMISSION REPORT.

BIOLOGICAL DATA

Biotope sampled:	Sampling device:
A) bottom sediment	corer

Mesh size = 300 μm. Samples are all one-off collections.

CHEMICAL DATA
Only chemical data for which there are matching biological data are included. Values given are for the dry season. The following variables were measured:
- temperature (TEMP), °C
- pH (PH)
- conductivity (COND), micromhos, converted to mS m^{-1}
- total dissolved solids (TDS), mg ℓ^{-1}
- dissolved oxygen (DO), mg ℓ^{-1}
- percentage saturation dissolved oxygen (DOPER), %
- Kjeldahl nitrogen (KJN), mg ℓ^{-1}
- nitrate (NO3-N), mg ℓ^{-1}
- phosphate, mg ℓ^{-1} assumed equivalent to SRP
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ converted to meq ℓ^{-1}
- total hardness (CACO3), mg ℓ^{-1} $CaCO_3$
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- fluoride (F), mg ℓ^{-1}
- free carbon dioxide (FREE CO2), mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
The biological and the chemical data have been matched for each site.

STUDY REFERENCE: 31

RIVER	VAAL RIVER
REFERENCE	CHUTTER F.M. 1967. HYDROBIOLOGICAL STUDIES ON THE VAAL RIVER. NATIONAL INSTITUTE FOR WATER RESEARCH, CSIR REPORT WAT 38 .

This report consists of two main studies. They will be outlined separately.

VAAL DAM REGION: Preliminary survey in September 1958-February 1959. Main survey in July 1959-October 1960. Final survey in August 1961. (Sites VAL1, VAL2A, VAL3, VAL4, VAL5, VAL5A, VAL7, VAL8, VAL9, VAL10, VAL11A, VAL11B, VAL11C, VAL11X, VAL12, VAL13, VAL14, VAL17, VAL19, VAL21, VAL21A, VAL22, VAL24, VAL24A, VAL25, VAL26, VAL27, VAL29, VAL30, VAL31, VAL33, VAL34, VAL36, VAL38, VAL39, VAL40, VAL41, VAL42, VAL43, VAL44).

BIOLOGICAL DATA

Biotopes sampled:		Sampling devices:
A) stony bottom:	stone-in-current	Surber sampler or hand net
	backwater	hand net
B) vegetation:	marginal vegetation	hand net

Mesh size » 950 μm. Sites were sampled during the following three seasons: WIN.58-61: winter (late April to August); DES.58-61: dry early summer (September to November); SUM.58-61 (end of November to March). The biological data are given as the mean seasonal percentages for each site. Rare species were recorded as being present or absent.

CHEMICAL DATA
Water samples for chemical analysis were collected simultaneously to the biological data, but have not always been presented in the same manner. Determinands varied between sites and with season. The following variables were measured at some or all of the sites, and mean, maximum and minimum values were given for nearly all of them :
- pH (PH)

- total dissolved solids (TDS), mg ℓ^{-1}
- nitrate (NO3-N), mg ℓ^{-1}
- nitrite (NO2-N), mg ℓ^{-1}
- nitrite + nitrate (NO2+NO3), mg ℓ^{-1}
- ammonium (NH4-N), mg ℓ^{-1}
- total nitrogen (TOT-N), mg ℓ^{-1}
- Kjeldahl nitrogen (KJN), mg ℓ^{-1}
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ converted to meq ℓ^{-1}
- total hardness (CACO3), mg ℓ^{-1} $CaCO_3$
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- turbidity (TURB), as mg ℓ^{-1} SiO_2

MATCHING BIOLOGICAL AND CHEMICAL DATA
Because of differences in the presentation of the biological and chemical data, matching was problematic. Mean, minimum and maximum values for 1957-1958 are given for sites VAL1, VAL2A, VAL3, VAL4, VAL5, VAL5A, VAL17, VAL19, VAL20, VAL21, VAL21A. These have not been matched with biological data because the latter were given for each season. Spot chemical data are given for August 1961, for sites VAL9, VAL10, VAL11A, VAL11B, VAL11X, VAL13, VAL24, VAL25, VAL26, VAL30, VAL41, VAL42, VAL44. These have been matched with biological data for WIN.58-61. Caution should be used when using the combined biological and chemical data.

VAAL RIVER IN THE WARRENTON AREA
Each site was sampled in October 1963, January 1964, April 1964 and August 1964 (sites VAL51, VAL52, VAL53, VAL54, VAL54A, VAL55, VAL55A, VAL56).

BIOLOGICAL DATA

Biotopes sampled:		Sampling devices:
A) stony bottom:	stone-in-current	collection of fauna associated with individual stones (5 per site)
B) vegetation:	marginal vegetation	hand net

Mesh size » 950 μm. Data are given as the mean number of animals per surface area of stone. Rare species were recorded as being present or absent .

CHEMICAL DATA
Water samples for chemical analysis were collected at the same time as the biological data. Determinands varied between sites and with season. The following variables were measured at some or all of the sites:

- temperature (TEMP), °C
- pH (PH)
- total dissolved solids (TDS), mg ℓ^{-1}
- total suspended solids (TSS), mg ℓ^{-1}
- nitrate (NO3-N), mg ℓ^{-1}
- nitrite (NO2-N), mg ℓ^{-1}
- ammonium (NH4-N), mg ℓ^{-1}
- Kjeldahl nitrogen (KJN), mg ℓ^{-1}
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ converted to meq ℓ^{-1}
- total hardness (CACO3), mg ℓ^{-1} $CaCO_3$
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- turbidity (TURB), as mg ℓ^{-1} SiO_2

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological and chemical data were matched for each sampling period. Some chemical data were obtained at unspecified dates between 1957 and 1958 (dated "1957-58" in database), and thus no biological-chemical date link was possible for these sites.

STUDY REFERENCE: 32

RIVER	ORANGE RIVER
REFERENCE	DE MOOR F.C. & CAR M. 1986. A FIELD EVALUATION OF *BACILLUS THURINGIENSIS* VAR. *ISRAELENSIS* AS A BIOLOGICAL CONTROL AGENT FOR *SIMULIUM CHUTTERI* (DIPTERA: NEMATOCERA) IN THE MIDDLE ORANGE RIVER. J. VET. RES. 53: 43-50.

BIOLOGICAL DATA

Biotope sampled:		Sampling device:
A) stony bottom:	stones-in-current	hand collection of stones

Mesh size = 92 μm. Biota associated with 5 stones were collected at each site prior to treatment.

CHEMICAL DATA
Only pH (PH), conductivity (COND), mS m^{-1}, turbidity (NTU), and flow were measured, on a one-off basis.

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological and chemical data were matched directly.

STUDY REFERENCE: 33

RIVERS	JUKSKEI-CROCODILE RIVER SYSTEM
REFERENCE	ALLANSON B.R. 1961. INVESTIGATIONS INTO THE ECOLOGY OF POLLUTED INLAND WATERS IN THE TRANSVAAL. PART 1. THE PHYSICAL, CHEMICAL AND BIOLOGICAL CONDITIONS IN THE JUKSKEI-CROCODILE RIVER SYSTEM. HYDROBIOLOGIA 18: 1-76.

BIOLOGICAL DATA

Biotopes sampled:		Sampling devices:
A) stony bottom:	stone-in-current (stickles and cascades)	Surber sampler
B) vegetation:	marginal vegetation	hand net
C) sediment:	bottom mud/sand in pools	scoop

Mesh size » 950 μm. Samples were collected monthly but have not always been presented as such. The following biological data are given: monthly abundance at sites ALL2, ALL3, ALL6, ALL19, ALL21, ALL23; those present in winter or summer 1956-1957 (WIN.56-57: April to October; SUM.56-57: November to January/March respectively, indicated with as present since no abundance value was given); chironomid presence during the study period (1956-1957); and those associated with sandy sediments in winter 1958.

CHEMICAL DATA
Water samples for chemical analysis were collected simultaneously to the biological data, but have not always been presented in the same manner. Determinands varied between sites and with season. The following variables were measured at some or all of the sites (mean, minimum and maximum values normally given):

- pH (PH)
- conductivity (COND), in micromhos and converted to mS m^{-1}
- total dissolved solids (TDS), mg ℓ^{-1}
- total alkalinity (TAL), as mg ℓ^{-1} $CaCO_3$, converted to meq ℓ^{-1}

- total hardness (CACO3), mg ℓ^{-1} $CaCO_3$
- dissolved oxygen (DO), mg ℓ^{-1} (mean values only)
- percentage saturation dissolved oxygen (DOPER), % (mean values only)
- biological oxygen demand (BOD), mg ℓ^{-1} (mean values only)
- nitrate (NO3-N), mg ℓ^{-1}
- nitrite (NO2-N), mg ℓ^{-1}
- ammonium (NH4-N), mg ℓ^{-1}
- calcium (CA), as mg ℓ^{-1} $CaCo_3$, converted to mg ℓ^{-1} Ca
- magnesium (MG), as mg ℓ^{-1} $CaCo_3$, converted to mg ℓ^{-1} Mg
- sulphate (SO4), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- turbidity (TURB), as mg ℓ^{-1} SiO_2

MATCHING BIOLOGICAL AND CHEMICAL DATA
Because of differences in the presentation of the biological and chemical data, matching was problematic. Mean, minimum and maximum values for the monthly sites have been matched with the relevant monthly chemical data. Biological data from SUM.56-57 and WIN.56-57 have been matched with the same chemical data. In many cases, chemical data for SUM.56-57 have, by convention, been matched with the biological data of February 1957.

STUDY REFERENCE: 34

RIVERS	KLIPSPRUIT, KLIP (NEAR OLIFANTSVLEI), SADELBOOM AND KLIP RIVERS (NEAR WITBANK)
REFERENCE	HARRISON A.D. 1958C. THE EFFECTS OF SULPHURIC ACID POLLUTION ON THE BIOLOGY OF STREAMS IN THE TRANSVAAL, SOUTH AFRICA. VERH. INTERNAT. VER. LIMNOL. 23: 603-610.

BIOLOGICAL DATA

Biotope sampled:		Sampling device:
A) stony bottom:	stone-in-current	hand net
B) vegetation:	aquatic vegetation	hand net
	submerged vegetation	hand net
C) mixture of all biotopes		

Mesh size = > 950 μm. Fauna of the aquatic vegetation was sampled on the Klipspruit and Klip rivers in October 1954, January 1955, April 1955 and July 1955. Fauna from stones-in-current and submerged vegetation was sampled on the Sadelboom River in May 1956 and the Klip River in May 1956 and November 1956.

CHEMICAL DATA
Chemical samples were taken at the same time as biological samples. The following variables are reported (normally as a mean and/or, minimum and maximum).

- pH (PH)
- total dissolved solids (TDS), mg ℓ^{-1}
- nitrate (NO3-N), mg ℓ^{-1}
- ammonium (NH4-N), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- calcium (CA), given as mg ℓ^{-1} $CaCO_3$ and converted to mg ℓ^{-1} Ca
- magnesium (MG), given as mg ℓ^{-1} $MgCO_3$ and converted to mg ℓ^{-1} Mg

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological and chemical data were matched directly.

STUDY REFERENCE: 35

RIVER BERG RIVER, WESTERN CAPE PROVINCE

REFERENCE COETZER A. 1978. THE INVERTEBRATE FAUNA AND BIOTIC INDEX VALUE OF WATER QUALITY OF THE GREAT BERG RIVER, WESTERN CAPE. JOURNAL OF THE LIMNOLOGICAL SOCIETY OF SOUTHERN AFRICA 4(1): 1-7.

BIOLOGICAL DATA

Biotopes sampled:		Sampling device:
A) stony bottom:	stones-in-current	Surber sampler (3 samples per site-pooled)

Mesh size = 290 μm. Sampling was conducted between April 1978 and March 1979. The mean number of animals per season were calculated for each site. The following seasons were defined: EW = early winter (April, May, June); W = wet winter (July, August, September); ED = early dry summer (October, November, December) and D = dry summer (January, February, March).

CHEMICAL DATA

Chemical samples were collected at the same time as biological samples. The following variables were reported (conversions and assumptions are detailed:)

- temperature (TEMP), °C
- pH (PH)
- conductivity (COND), μS cm^{-1}, converted to mS m^{-1}
- total suspended solids (TSS), mg ℓ^{-1}
- percentage saturation dissolved oxygen (DOPER), %
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ and converted to meq ℓ^{-1}
- total hardness (CACO3), mg ℓ^{-1} $CaCO_3$
- Combined nitrogen: (ammonium + nitrite + nitrate) (NH4 + NO3 + NO2)-N), mg ℓ^{-1}
- orthophosphate, assumed equivalent to soluble reactive phosphorus (SRP), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA

Biological and chemical data were matched directly on a seasonal basis.

STUDY REFERENCE: 36

RIVER OLIFANTS RIVER, WESTERN CAPE PROVINCE

REFERENCE COETZER A. 1982. HYDROBIOLOGICAL REPORT ON THE OLIFANTS RIVER SYSTEM, WESTERN CAPE PROVINCE. REPORT OF RESEARCH SECTION, DEPARTMENT OF NATURE CONSERVATION.

BIOLOGICAL DATA

Biotopes sampled:		Sampling device:
A) stony bottom:	stone-in-current	Surber sampler (3 samples per site-pooled)

Mesh size = 290 μm. Sampling was conducted between April 1978 and March 1979. The mean number of animals per season were calculated for each site. The following seasons were defined: EW = early winter (April, May, June); W = wet winter (July, August, September); ED = early dry summer (October, November, December) and D = dry summer (January, February, March).

CHEMICAL DATA

Chemical samples were collected simultaneously to biological samples. The following variables were reported (conversions and assumptions are detailed:)

- temperature (TEMP), °C
- pH (PH)
- conductivity (COND), μS cm^{-1}, converted to mS m^{-1}
- total suspended solids (TSS), mg ℓ^{-1}
- percentage saturation dissolved oxygen (DOPER), %

- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ and converted to meq ℓ^{-1}
- hardness (CACO3), mg ℓ^{-1}
- N-combined: [ammonia+nitrite+nitrate ($NH_3+NO_3+NO_2$)], mg ℓ^{-1}
- orthophosphate, assumed equivalent to SRP, mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological and chemical data were matched directly on a seasonal basis.

STUDY REFERENCE: 37

RIVER	LETABA RIVER
REFERENCE	CHUTTER F.M. & HEATH R.G.M. 1992. RELATIONSHIP BETWEEN LOW FLOWS AND THE RIVER FAUNA IN THE LETABA RIVER. PROGRESS REPORT PREPARED FOR THE WATER RESEARCH COMMISSION STEERING COMMITTEE MEETING OF 24.08.92. PROJECT NO. K5/293.

BIOLOGICAL DATA

Biotope sampled:		Sampling device:
A) stony bottom:	stones-in-current	hand net

Mesh size = 300 μm. A complete distribution table is given for all sites (monthly data combined for each site). Biological data from sites LET6, LET8 and LET9 are given separately for February, May, August and November 1990, and February, May, August and November 1991.

CHEMICAL DATA
Chemical samples were collected at the same time as biological samples. The following variables were reported (conversions and assumptions are detailed:)

- temperature (TEMP), °C
- pH (PH)
- conductivity (COND), mS m^{-1} at 25°C
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ and converted to meq ℓ^{-1}
- Kjeldahl nitrogen (KJN), in μg ℓ^{-1} and converted to mg ℓ^{-1}
- nitrate + nitrite (NO2+NO3), in μg ℓ^{-1} and converted to mg ℓ^{-1}
- orthophosphate, assumed equivalent to SRP, in μg ℓ^{-1} and converted to mg ℓ^{-1}
- ammonium (NH4-N), in μg ℓ^{-1} and converted to mg ℓ^{-1}
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- turbidity (NTU), in NTUs

MATCHING BIOLOGICAL AND CHEMICAL DATA
Only the monthly biological and chemical data given for sites LET6, LET8 and LET9 were matched.

STUDY REFERENCE: 38

RIVER	PALMIET RIVER, WESTERN CAPE PROVINCE
REFERENCE	GALE B.A. 1992. THE EFFECT OF REGULATION BY TWO IMPOUNDMENTS ON AN ACID, BLACKWATER, CAPE MOUNTAIN STREAM. PHD THESIS. ZOOLOGY DEPARTMENT. UNIVERSITY OF CAPE TOWN, SOUTH AFRICA.

BIOLOGICAL DATA

Biological sampling was conducted monthly. Mesh size = 80 μm.

Biotope sampled:		Sampling device:
A. stony bottom:	stone-in-current (riffle)	Box sampler

CHEMICAL DATA
Chemical samples were collected at the same time as biological samples. The following variables were measured:

- temperature (TEMP), °C
- pH (PH)
- conductivity (COND), μS cm^{-1}, converted to mS m^{-1}
- total dissolved solids (TDS), mg ℓ^{-1}
- percentage saturation dissolved oxygen (DOPER), %
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ and converted to meq ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- nitrate (NO3-N), mg ℓ^{-1}
- nitrite (NO2-N), mg ℓ^{-1}
- ammonium (NH4-N), mg ℓ^{-1}
- Soluble Reactive Phosphorus (SRP), mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological and chemical data were matched directly.

STUDY REFERENCE: 39

RIVER	LOURENS RIVER, WESTERN CAPE PROVINCE
REFERENCE	RACTLIFFE G. 1991. THE EFFECTS OF SUSPENDED SEDIMENTS ON THE MACROINVERTEBRATE COMMUNITY STRUCTURE OF A RIVER ECOSYSTEM. HONOURS THESIS, ZOOLOGY DEPARTMENT, UNIVERSITY OF CAPE TOWN.

BIOLOGICAL DATA

Biotope sampled:		Sampling device:
A. stony bottom:	stone-in-current (riffle)	Box sampler

Mesh size = 80 μm.

CHEMICAL DATA
Chemical samples were collected at the same time as biological samples. The detection limit for the nutrients was 0.5 mg ℓ^{-1}. The following variables were measured:

- temperature (TEMP), °C
- pH (PH)
- conductivity (COND), μS cm^{-1}, converted to mS m^{-1}
- percentage saturation dissolved oxygen (DOPER), %
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ and converted to meq ℓ^{-1}
- nitrate-nitrogen (NO3-N), mg ℓ^{-1}
- ammonium-nitrogen (NH4-N), mg ℓ^{-1}
- orthophosphates (PO4-P), assumed equivalent to SRP, mg ℓ^{-1}
- Chemical Oxygen Demand (COD), mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological data for July and August were linked to chemical data for June.

STUDY REFERENCE: 40

RIVER	EERSTE RIVER, WESTERN CAPE PROVINCE
REFERENCE	KING J.M. 1983. ABUNDANCE, BIOMASS AND DIVERSITY OF BENTHIC

MACRO-INVERTEBRATES IN A WESTERN CAPE RIVER, SOUTH AFRICA. TRANSACTIONS OF THE ROYAL SOCIETY OF SOUTHERN AFRICA. 45:11-33

BIOLOGICAL DATA
Sampling was conducted monthly between March 1975 and April 1976. Samples were however combined and data were presented seasonally for March-May, June-August, September-November and December-February. Mesh size = 0.6 mm.

Biotope sampled:		Sampling device:
A. stony bottom:	stone-in-current (riffle)	Box sampler

CHEMICAL DATA
Chemical data were collected simultaneously to biological data but are given as May-August and December-March means. The following variables were measured:

- temperature (TEMP), °C
- pH (PH)
- percentage saturation dissolved oxygen (DOPER), %
- dissolved oxygen (DO), mg ℓ^{-1}
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ and converted to meq ℓ^{-1}
- nitrite-nitrogen (NO2-N), mg ℓ^{-1}
- nitrate-nitrogen (NO3-N), mg ℓ^{-1}
- total phosphorus (TOT-P), mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological data for June-August have been linked to chemical data for May-August, and December-February to December-March.

STUDY REFERENCE: 41

RIVERS	VARIOUS RIVERS IN THE WESTERN CAPE (E.G. BERG RIVER AND TRIBUTARIES, KRAALSTROOM, EERSTE, MOLENAARS, PALMIET, OLIFANTS RIVERS)
REFERENCE	DALLAS H.F. 1994. AN EVALUATION OF SASS (SOUTH AFRICAN SCORING SYSTEM) AS A TOOL FOR THE RAPID ASSESSMENT OF WATER QUALITY. MSC THESIS. ZOOLOGY DEPARTMENT, UNIVERSITY OF CAPE TOWN, SOUTH AFRICA.

BIOLOGICAL DATA
SASS (South African Scoring System) sampling was conducted using a 950 μm mesh. A mixture of biotopes were sampled and data pooled.

Biotope sampled:		Sampling device:
A. mixed:	all available biotopes, (e.g. sic, sooc, mv, aqv, sand)	SASS Kick net

CHEMICAL DATA
Chemical samples were collected at the same time as biological samples. The following variables were measured:

- temperature (TEMP), °C
- conductivity (COND), μS cm^{-1}, converted to mS m^{-1}
- pH (PH)
- total dissolved solids (TDS), mg ℓ^{-1}
- total suspended solids (TSS), mg ℓ^{-1}
- total organics (TORGS), mg ℓ^{-1}
- dissolved oxygen (DO), mg ℓ^{-1}
- nitrate (NO3-N), mg ℓ^{-1}
- nitrite (NO2-N), mg ℓ^{-1}
- ammonium (NH4-N), mg ℓ^{-1}

- Soluble Reactive Phosphorus (SRP), mg ℓ^{-1}
- silica, mg ℓ^{-1}
- total alkalinity (TAL), meq ℓ^{-1}
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- aluminium, mg ℓ^{-1}
- iron, mg ℓ^{-1}
- lead, mg ℓ^{-1}
- phenols, mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological and chemical data were matched directly.

STUDY REFERENCE: 42

RIVER PALMIET RIVER, WESTERN CAPE PROVINCE

REFERENCE DE DECKER H.P. 1981. CHANGES IN THE COMMUNITY STRUCTURE OF BENTHIC MACROINVERTEBRATES IN THE STONY-BED AREAS OF THE PALMIET RIVER, IN RELATION TO THE PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE RIVER. HONOURS THESIS, ZOOLOGY DEPARTMENT, UNIVERSITY OF CAPE TOWN, SOUTH AFRICA.

BIOLOGICAL DATA
Biological sampling was conducted in March and August 1981. Mesh size = 0.6 mm.

Biotope sampled:		Sampling device:
A. stony bottom:	stone-in-current (riffle)	Box sampler

CHEMICAL DATA
Chemical samples were collected at the same time as biological samples. The following variables were measured:

- temperature (TEMP), °C
- pH (PH)
- percentage saturation dissolved oxygen (DOPER), %
- nitrate (NO3-N), mg ℓ^{-1}
- nitrite (NO2-N), mg ℓ^{-1}
- Soluble Reactive Phosphorus (SRP), mg ℓ^{-1}
- silica, mg ℓ^{-1}

MATCHING BIOLOGICAL AND CHEMICAL DATA
Biological and chemical data were matched directly.

STUDY REFERENCE: 43

RIVER UMGENI RIVER, WESTERN CAPE PROVINCE

REFERENCE SCHOONBEE H.J. 1964. A HYDROBIOLOGICAL INVESTIGATION OF THE UMGENI RIVER SYSTEM, NATAL, AND ITS BEARING ON THE ECOLOGICAL INTERPRETATION OF FAUNAL COMMUNITIES IN SOUTH AFRICAN RIVERS. PHD THESIS, ZOOLOGY DEPARTMENT, POTCHEFSTROOM UNIVERSITY, SOUTH AFRICA.

BIOLOGICAL DATA
Biological data are given for each season, with a further division into early and late in some

instances. Mesh size approximately 500 μm.

Biotopes sampled:		Sampling devices:
A) stony bottom:	in stickles	Surber sampler or hand net
	in run	Surber sampler or hand net
	in cascade	hand net
	in flats	Surber sampler or hand net
	in backwaters	hand net
	in pool	Surber sampler or hand net
B) vegetation:	marginal vegetation	hand net
	stream bottom vegetation	hand net

CHEMICAL DATA

Composite and snap samples of water were taken throughout the period 1959 to 1960. Data are presented as mean, minimum and maximum values for the entire period. The following variables were measured:

- pH (PH)
- conductivity (COND), in micromhos at 20 °C, converted to mS m^{-1}
- total dissolved solids (TDS), mg ℓ^{-1}
- biological oxygen demand (BOD), 5 days at 20 °C, mg ℓ^{-1}
- total alkalinity (TAL), mg ℓ^{-1} $CaCO_3$ and converted to meq ℓ^{-1}
- total hardness (CACO3), mg ℓ^{-1} $CaCO_3$
- calcium (CA), mg ℓ^{-1}
- magnesium (MG), mg ℓ^{-1}
- sulphate (SO4), mg ℓ^{-1}
- sodium (NA), mg ℓ^{-1}
- potassium (K), mg ℓ^{-1}
- chloride (CL), mg ℓ^{-1}
- silica, mg ℓ^{-1}
- nitrate (NO3-N), mg ℓ^{-1}
- nitrite (NO2-N), mg ℓ^{-1}
- free and saline ammonia, assumed equivalent to ammonium (NH4-N), mg ℓ^{-1}
- phosphate, assumed equivalent to Soluble Reactive Phosphorus (SRP), mg ℓ^{-1}
- turbidity (TURB), as mg ℓ^{-1} SiO_2

MATCHING BIOLOGICAL AND CHEMICAL DATA

Analysis of the chemical data by the author indicated minimal seasonal differences in physical and chemical variables. The seasonal biological data was therefore matched to the composite chemical data.

Appendix H. List of all water quality variables for which there are records in the Biological and Chemical Database.

Code	Description	Unit
%ORG IN TSS	Percentage organic material in TSS	%
(NH4+NO3+NO2)-N	Combined nitrogen	mg ℓ^{-1}
AL	Aluminium concentration	mg ℓ^{-1}
BOD	Biological Oxygen Demand	mg ℓ^{-1} (5 days)
BODMAX	Biological Oxygen Demand (maximum)	mg ℓ^{-1} (5 days)
BODMIN	Biological Oxygen Demand (minimum)	mg ℓ^{-1} (5 days)
CA	Calcium	mg ℓ^{-1}
CACO3	CaCO3 as a measure of total hardness	mg ℓ^{-1}
CACO3MAX	CaCO3 (maximum)	mg ℓ^{-1}
CACO3MIN	CaCO3 (minimum)	mg ℓ^{-1}
CAMAX	Calcium (maximum)	mg ℓ^{-1}
CAMIN	Calcium (minimum)	mg ℓ^{-1}
CHLA	Chlorophyll *a*	mg ℓ^{-1}
CL	Chloride	mg ℓ^{-1}
CLMAX	Chloride (maximum)	mg ℓ^{-1}
CLMIN	Chloride (minimum)	mg ℓ^{-1}
CO3	Carbonate	mg ℓ^{-1}
COD	Chemical Oxygen Demand	mg ℓ^{-1}
COL	Colour	APHA units
COLMAX	Colour (maximum)	APHA units
COLMIN	Colour (minimum)	APHA units
COND	Conductivity	mS m^{-1}
CONDMAX	Conductivity (maximum)	mS m^{-1}
CONDMIN	Conductivity (minimum)	mS m^{-1}
DIN	Dissolved inorganic nitrogen	mg ℓ^{-1}
DO	Dissolved oxygen	mg ℓ^{-1}
DON	Dissolved organic nitrogen	mg ℓ^{-1}
DOPER	% saturation of dissolved oxygen	%
F	Fluoride	mg ℓ^{-1}
FE	Iron	mg ℓ^{-1}

FEMAX	Iron (maximum)	mg ℓ^{-1}
FEMIN	Iron (minimum)	mg ℓ^{-1}
FREE CO2	Free carbon dioxide/carbonic acid	mg ℓ^{-1}
HCO3	Bicarbonate	mg ℓ^{-1}
K	Potassium	mg ℓ^{-1}
KJN	Kjeldahl nitrogen	mg ℓ^{-1}
KMAX	Potassium (maximum)	mg ℓ^{-1}
KMIN	Potassium (minimum)	mg ℓ^{-1}
MG	Magnesium	mg ℓ^{-1}
MGMAX	Magnesium (maximum)	mg ℓ^{-1}
MGMIN	Magnesium (minimum)	mg ℓ^{-1}
NA	Sodium	mg ℓ^{-1}
NAMAX	Sodium (maximum)	mg ℓ^{-1}
NAMIN	Sodium (minimum)	mg ℓ^{-1}
NH4-N	Ammonia nitrogen	mg ℓ^{-1}
NH4MAX	Ammonia nitrogen (maximum)	mg ℓ^{-1}
NH4MIN	Ammonia nitrogen (minimum)	mg ℓ^{-1}
NO2+NO3	Nitrate nitrogen + nitrite nitrogen	mg ℓ^{-1}
NO2-N	Nitrite nitrogen	mg ℓ^{-1}
NO2MAX	Nitrite nitrogen (maximum)	mg ℓ^{-1}
NO2MIN	Nitrite nitrogen (minimum)	mg ℓ^{-1}
NO3-N	Nitrate nitrogen	mg ℓ^{-1}
NO3MAX	Nitrate nitrogen (maximum)	mg ℓ^{-1}
NO3MIN	Nitrate nitrogen (minimum)	mg ℓ^{-1}
PB	Lead concentration	mg ℓ^{-1}
pH	pH	pH units
PHALK	Phenolthalein alkalinity	meq ℓ^{-1}
PHEN	Phenols	mg ℓ^{-1}
PHMAX	pH (maximum)	pH units
PHMIN	pH (minimum)	pH units
POM	Particulate organic matter	mg ℓ^{-1}
SI	Silica	mg ℓ^{-1}
SIMAX	Silica (maximum)	mg ℓ^{-1}
SIMIN	Silica (minimum)	mg ℓ^{-1}

SO4	Sulphate	mg ℓ^{-1}
SO4MAX	Sulphate (maximum)	mg ℓ^{-1}
SO4MIN	Sulphate (minimum)	mg ℓ^{-1}
SRP	Soluble reactive sulphate (often assumed = PO4-P)	mg ℓ^{-1}
SRPMAX	Soluble reactive sulphate (maximum)	mg ℓ^{-1}
SRPMIN	Soluble reactive sulphate (minimum)	mg ℓ^{-1}
TAL	Total alkalinity	meq ℓ^{-1}
TALMAX	Total alkalinity (maximum)	meq ℓ^{-1}
TALMIN	Total alkalinity (minimum)	meq ℓ^{-1}
TDS	Total dissolved solids	mg ℓ^{-1}
TDSMAX	Total dissolved solids (maximum)	mg ℓ^{-1}
TDSMIN	Total dissolved solids (minimum)	mg ℓ^{-1}
TEMP	Temperature	degrees C
TIC	Total inorganic carbon	mg ℓ^{-1}
TMAX	Temperature (maximum)	degrees C
TMIN	Temperature (minimum)	degrees C
TOC	Total organic carbon	mg ℓ^{-1}
TORGS	Total organics in TSS	mg ℓ^{-1}
TOT-N	Total nitrogen	mg ℓ^{-1}
TOT-P	Total phosphorus	mg ℓ^{-1}
TSS	Total suspended solids	mg ℓ^{-1}
TSSMAX	Total suspended solids (maximum)	mg ℓ^{-1}
TSSMIN	Total suspended solids (minimum)	mg ℓ^{-1}
TURBIDITY	Turbidity (NTU scale)	NTUs
TURBMAX	Turbidity (maximum)	NTU
TURBMIN	Turbidity (minimum)	NTU
TURBS (SIO2)	Turbidity (silica scale)	mg ℓ^{-1}
TURBSMAX (SIO2)	Turbidity (silica scale) (maximum)	mg ℓ^{-1}
TURBSMIN (SIO2)	Turbidity (silica scale) (minimum)	mg ℓ^{-1}